WIRE

JANUARY 1938

AND WIRE PRODUCTS

· MEMO TO MANAGEMENT ·

Subject: THE YEAR AHEAD

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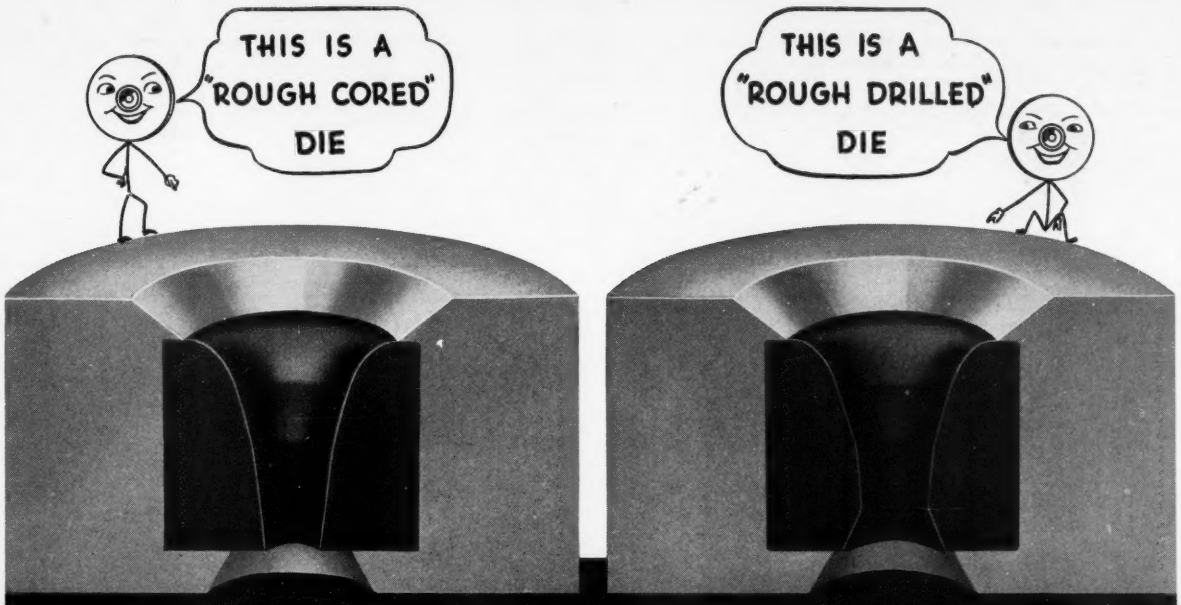

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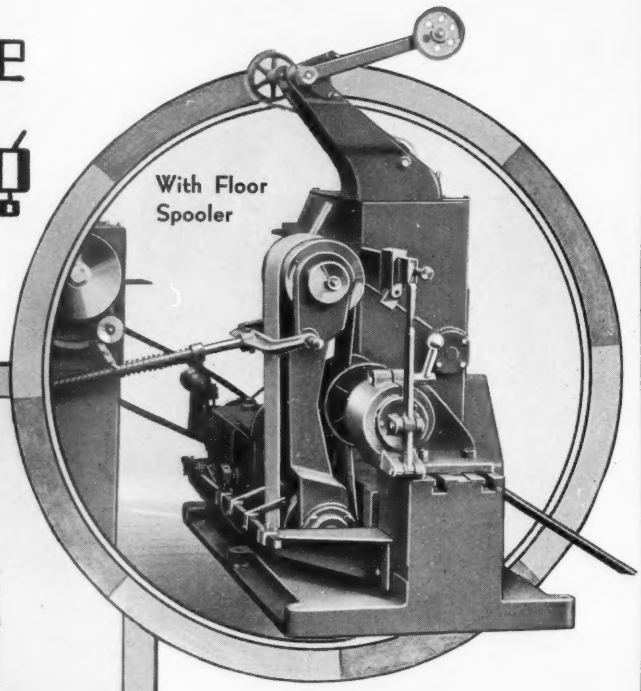
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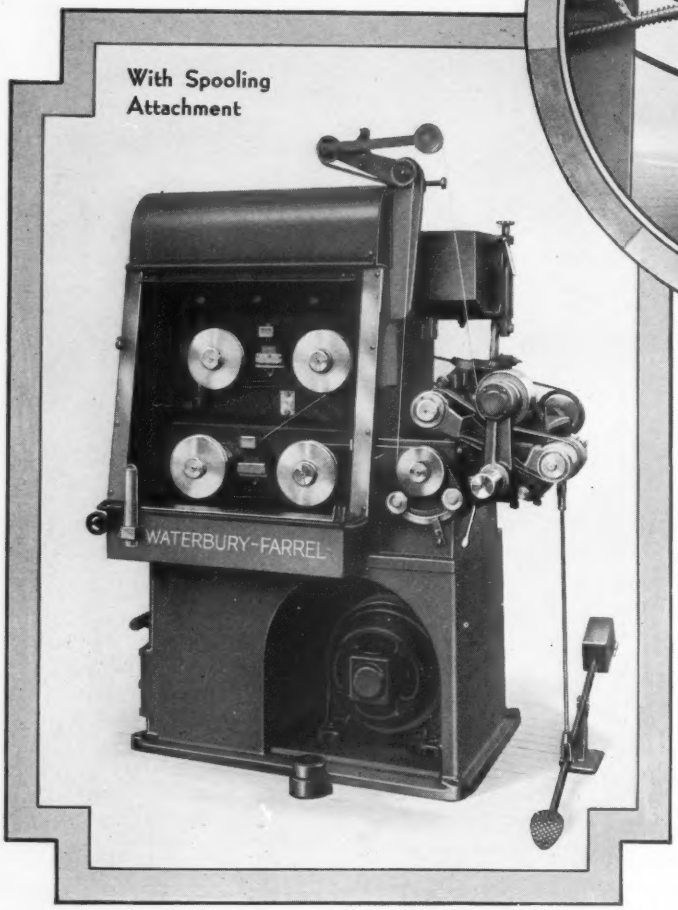

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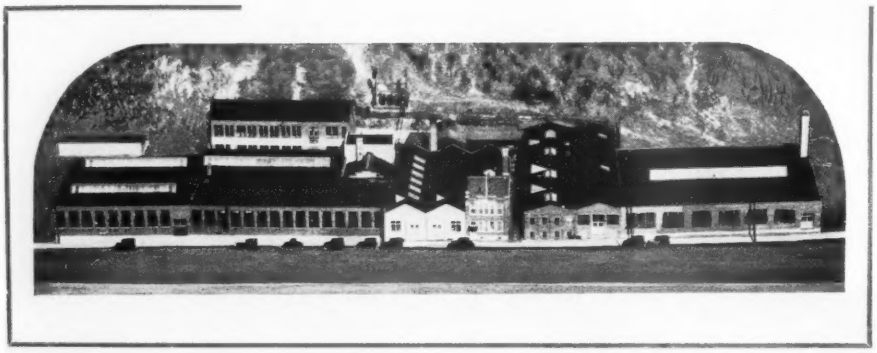

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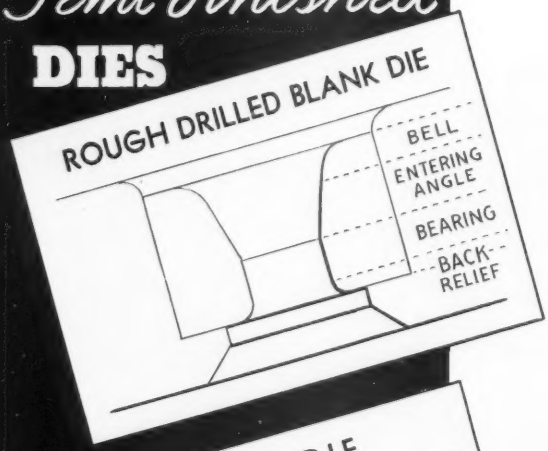

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DRAWING—ROLLING—EXTRUDING—FORMING—FABRICATING

Vol. 13 JANUARY, 1938 No. 1

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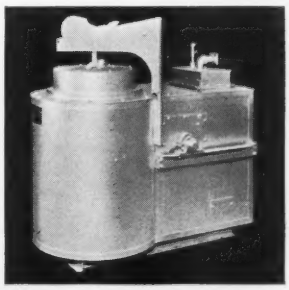

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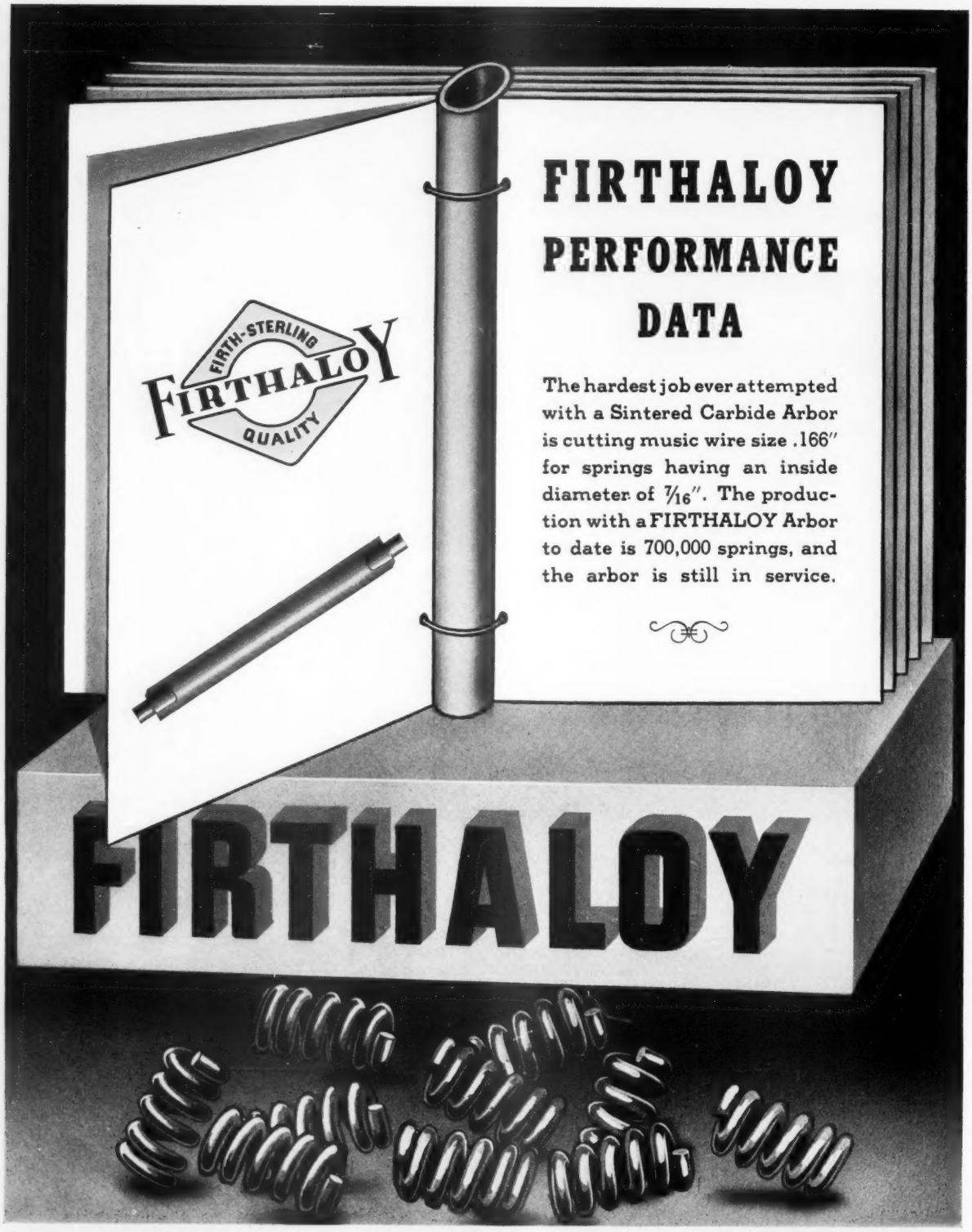
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WIRE AND WIRE PRODUCTS

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Wire Products and Insulated Wire and Cable.
DRAWING --- ROLLING--- EXTRUDING --- FORMING --- FABRICATING

Vol. 13 JANUARY, 1938 No. 1

Wires For Radio Tubes

By J. Delmonte*

Assistant to Chief Engineer of Development and Research
Chicago Flexible Shaft Co., Chicago, Ill.

Special processing methods applied to metals and alloys that are used in radio tube structures. A description of filament construction and methods of manufacture. ✦ ✦ ✦ ✦

WIRES and wire products fulfill important functions in the construction of every radio tube. While wire products are not used in large quantities in the individual application, the large number of tubes which are manufactured each year requires products which meet highly specialized requirements under exacting conditions. The metals and alloys that are used in tube wire structures are uncommon to applications other than electronics devices. In addition, they are subjected to special processing methods to render them fit for high temperature and high vacuum operations.

✦ ✦ ✦

THE most important part of the radio tube is the filament (cathode), which is the source of the electron stream. The electrons are attracted to the anode or plate, which is at a positive voltage with respect to the filament. The grids, placed between the anode and cathode, provide a measure of control over the electron stream.

✦ ✦ ✦

THE subject matter of this paper will be concerned primarily with wire filaments, grid wires and meshes, lead-in wires, wire hooks and supporting rods. The wire filaments should be discussed in terms of the electron-emission characteristics of metals, and the special treatments for enhancing these qualities. As the most practical method of producing free electrons at a metal surface is by thermal agitation, the phenomena of thermionic emission must be thoroughly investigated. Limiting considerations of melting points, 'hot-strengths', mechanical, and chemical characteristics must be examined while comparing the relative merits of the filament metals.

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Filament Construction

IN order to familiarize the reader with the more common forms of filament construction, attention is invited to Figure 1. In general, there are two types of cathodes: directly heated cathodes and indirectly heated cathodes. In the former types, the wire filament acts as the source of electrons which are emitted to the plate. These filaments are characterized by an almost instantaneous response to the heating effect of the electrical energy, when the power is turned on. Storage battery operated tubes, medium and high powered transmitting tubes use the directly heated cathode.

✦ ✦ ✦

IN the indirectly heated cathode, a filament or heater wire is surrounded by a high temperature insulating material, which in turn is surrounded by a cathode sleeve,

J. DELMONTE

*J. Delmonte, graduate of electrical engineering from New York University and Massachusetts Institute of Technology, has accepted a position as the assistant to chief engineer of development and research, Chicago Flexible Shaft Company. Mr. Delmonte will assist in the supervision of the design and development of electrical appliances. He was formerly connected with the Naval Aircraft Factory in Philadelphia, and with the Firestone Tire & Rubber Company as a research engineer.

which serves as the source of electrons when heated by the heater wires from the inside. Until the metallic cathode sleeve is brought up to operating temperature by the heater wires, the tube will not operate. In the early models, this delay amounted to fifty or sixty seconds. By improving the quality of the dielectric and decreasing the insulating wall to a minimum, it has been possible to reduce the time required for heating the cathode sleeve to ten seconds. The indirectly heated cathodes are used exclusively in small, low powered radio receiving tubes. They make possible operation of the filaments upon low voltage alternating current, as the shielding effect of the cathode sleeve eliminates the hum characteristics of a. c. operation. The cathode sleeves are uni-potential, as compared to the wire filaments, over which exist a fall in potential. An indirectly heated cathode is used in the typical radio receiving tubes illustrated in Figure 2. The wire grids of this tube are also recognizable, and attention will be called to them later in the paper.

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Filament Types

A NUMBER of the filament types illustrated in Figure 1, are taken from Moyer's book (1) on radio receiving tubes. The inverted V filament is one of the earliest types, as De Forest used this construction in his pioneer radio tubes which appeared during 1906 and 1907. The twisted wire filament (D) is one of the more common heater wires employed in indirectly heated cathodes. The cathode sleeve is not necessarily a thin cylindrical metallic shell. For example, a recently patented cathode consists of a number of recurrent loops of metallic strips, with filament wires in the focal points of each loop (See Figure 1G) (2). As a matter of fact, the cathode may be of a metallic ribbon formed to any desired shape. This fact is emphasized on examining the crinkled helical cathodes of the new power tubes for spot welding. A recent patent goes further in specifying that the emission from the cathode shall take place from discrete parts (3) (See Figure 1H). This signifies that a wire coil spaced at equal intervals or else a wire gauze may be used for emission purposes, in lieu of the solid sleeve in some instances.

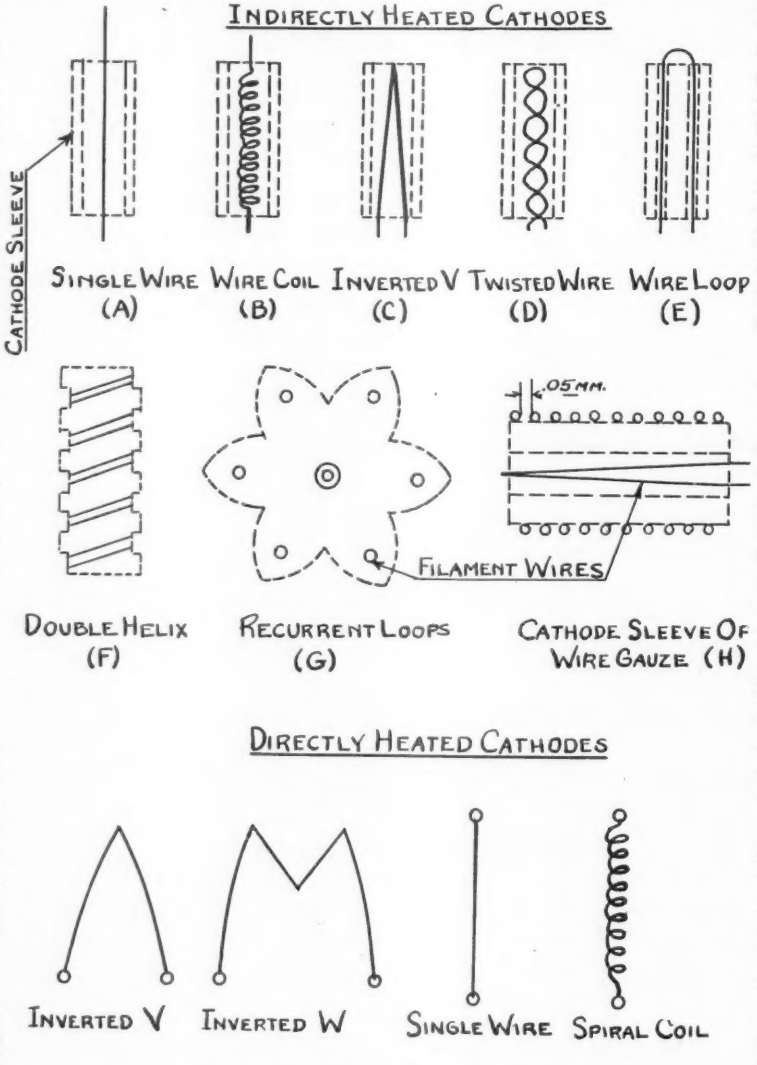

FIGURE 1

Fig. 1. Sketches of Filament Types.

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Thermionic Emission

TO **Richardson** we are indebted for the pioneer work in thermionic emission. His book derives the formula for thermionic emission from heated bodies as a function of the temperature (4). The principle of thermionic emission is employed in radio tubes, as the filaments are heated to operating temperatures by electrical energy to provide the electron stream. The formula for thermionic emission from heated bodies, which defines the relation between current density and the temperature is shown in Table A.

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THE significant term in this equation is ϕ, the work function. It is a constant of the surface of the material, and its appearance has been noted in photoelectric and corrosion phenomena. In the determination of the electron emitting qualities of a material, the work function is the most important factor. The metals with the highest work functions are the least effective electron emitters. However, a metal with a high melting point can be raised in temperature until its emission surpasses that of a low melting point metal, which does have a

lower work function. A high melting point is also desired in the electron emitter, as the emission varies as the square of the temperature. Attention is invited to Figure 3, which illustrates electron emission from several metals, as a function of the temperature. The differences which exist, depend for the great part, upon the variations in work function. For comparison purposes, Table I is given herewith, listing those metals and materials which are offered for wire filaments, and which could be used as electron emitters in radio tubes. The work function data are collected from several reliable sources (5), (6), and (7).

TABLE A

$$i = A\,T^{n} \exp\left(\frac{-e\,\phi}{k\,T}\right)$$

where

i—saturated current density at metal surface
T—absolute temperature
k—Boltzman's constant=1.371 . 10^{-16} erg/deg.
ϕ—Work Function of Metal
e—charge on electron=4.77 . 10^{-10} e. s. u.
A—constant of the metal
n—2 for the majority of metals

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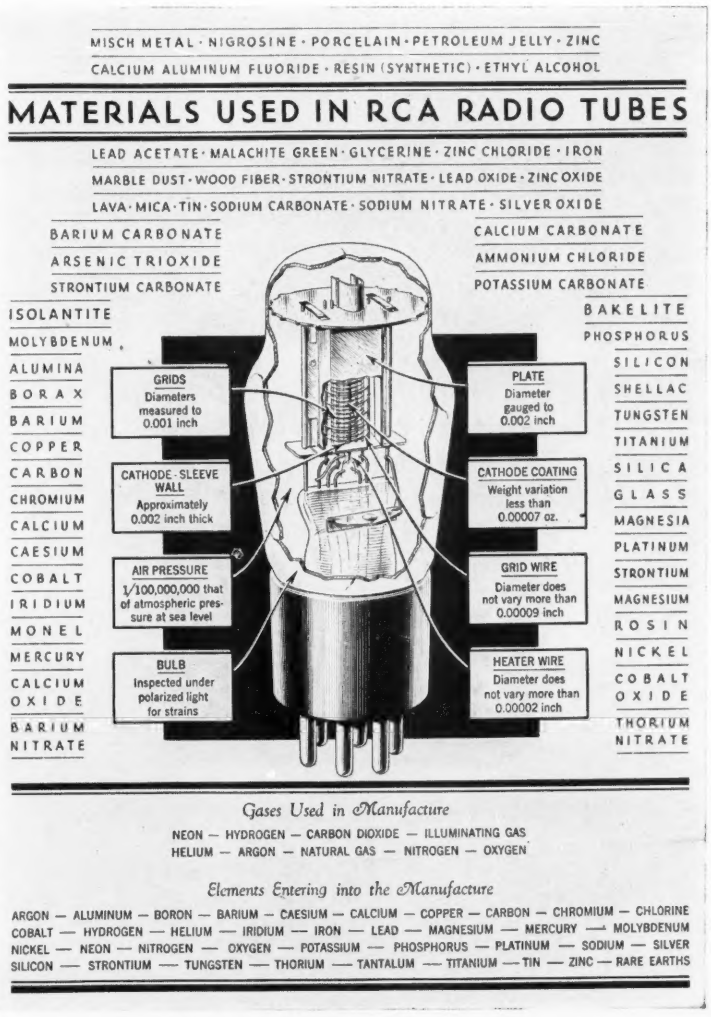
Tensile Strength Values

IN addition, in order to give some idea of the mechanical characteristics of the metals used as filaments, the tensile strength values are also given in Table I. The criteria for good electron emission are: low work function, and high melting point. Good tensile strength is also a prerequisite from practical wire drawing considerations. Tungsten is clearly outstanding from the viewpoint of temperature and strength. However, it is inefficient as an emitter, as it must be raised to higher temperatures than other metals — i. e. it requires more power to achieve the same emission. For low powered tubes, oxide coated cathodes are universally used. However, with increasing power demands and higher voltages, thoriated tungsten and tungsten filaments are resorted to.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Diameter does not vary more than 0.00002 inch
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NEON — HYDROGEN — CARBON DIOXIDE — ILLUMINATING GAS
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SILICON — STRONTIUM — TUNGSTEN — THORIUM — TANTALUM — TITANIUM — TIN — ZINC — RARE EARTHS

Fig. 2. Photo of RCA Tube and Materials—Courtesy of RCA. ✦ ✦

THE effect of adding an oxide coating to the filament metal core is to lower the work function very appreciably, leading to very efficient electron emission. Good results are also obtainable for the same reason, with thoriated tungsten. Attention is invited once again to Figure 3 and the curves of electron emission as functions of temperature; where the superiority of the thoriated and oxide coated filaments may be noted. A vast amount of research is under way at present to explain satisfactortorily the lowering of the work functions by the oxide filaments, and as this branch of the study is far from complete, this phenomenon will not be discussed in this paper.

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Application of Oxide Coatings

THE technique of applying an oxide coating to a wire filament, in order to insure satisfactory electron emission and long life, is not easy. Experience has shown that the alkaline earth oxides are the most satisfactory, particularly Barium oxide. The quantity of this oxide is usually diluted with a milder reagent as strontium oxide, to prevent segregation of the barium oxide in small centers of emission. In the application, it must be remembered that Barium and Barium oxide are not stable in air, and that they

must be applied in the form of a stable compound, which must be broken down during processing into the required oxide, and a gas, which may be removed from the tube. The stable alkaline earth compound usually selected is the carbonate, which will decompose at high temperatures.

TABLE I

Properties of Metals

Metal	Work Function Equiv. Volts	Melting Point Centigrade	Tensile Strength p. s. i.
Platinum	6.0	1755°	30-50,000
Silver	4.7	961°	40-45,000
Nickel	5.0	1452°	40-85,000
Iron (99.95%)	4.7	1530°	44,000
Tungsten	4.5	3370°	490,000
Molybdenum	4.4	2625°	260,000
Tantalum	4.1	2850°	130,000
Copper	4.0	1083°	35-62,000
Aluminum	3.0	658°	20-40,000
Barium Oxide	1.6	....	.....
Calcium Oxide	2.2	....	.....
Thoriated Tungsten	2.6	....	.....

✦ ✦ ✦

THERE are several methods employed for applying the oxide coating to the filament wires:

✦ ✦ ✦

1. A CORE wire of nickel or platinum is drawn through a fused salt bath of alkaline earth compound (as Barium Nitrate). This method is uncommon and not satisfactory as little control exists over the amount of compound applied to the wire. It is difficult to maintain some semblance of wire concentricity within the coating, due to the fact that on withdrawal from the bath, the weight of the compound tends to concentrate the material on the underside of the wire. This difficulty may be overcome partly by drawing the wire vertically from the bath and cooling immediately in a cold blast of air. However, the maintenance of a fused salt bath represents an operating cost not encountered by other methods, and the loss of reagents by volatilization must be accounted for.

✦ ✦ ✦

2. ANOTHER method of coating the wire requires the dipping of the wire into a water solution of salts, and the heating of the wire in carbon dioxide gas (8). This process is repeated for 50-100 times until the desired thickness of coating is achieved. In comparison with the other methods, this procedure is cumbersome and slow.

✦ ✦ ✦

3. THE paste method of applying the compounds to the wires is one of the most practical of the several methods. This method is likewise particularly suited for the cathode sleeves, which are warmed by the filament heater wires. Small particles of the compound, finely ground, are mixed into paste form with some organic gel or resin that is readily volatile on applying heat. The patent literature is replete with compounds and formulas which may be coated upon the cathode in a paste form. A few of the more common ones are listed below:

a. A pasty mixture of $BaCO_3$, $BaCl_2$, $SrCO_3$, and distilled water is heated in the presence of Oxygen to convert the $BaCl_2$ to Barium oxide at low temperatures, and Barium Carbonate to Barium oxide at high temperatures (9).

b. A cathode is coated with an alkaline earth carbonate, with the presence of 5% Nickel or Cobalt carbonate, and the combination subjected to a reducing operation (10).

c. A suitable composition for coating filaments exists in an alkaline earth metal oxalate or carbonate, including the acetate, formate, or azide, with a suitable binder (11).

d. The cathode may be shaped from a mass of materials, in which the alkaline earth metals are present as peroxides, which are decomposed by heat (12).

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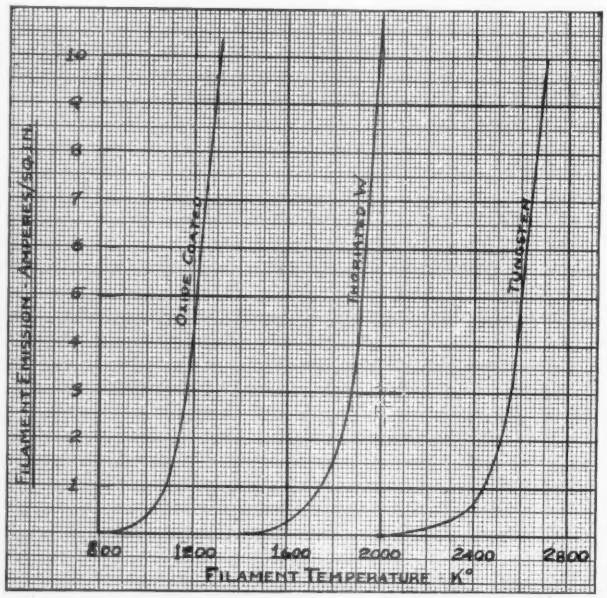

Fig. 3. Thermionic Emission Curves.

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4. ANOTHER practical method of applying the oxide coating is evident during the manufacture of the radio tube. This is accomplished by vaporizing the alkaline earth metal on to the core wire or filament, which is oxidized on the surface. The alkaline earth metal may be attached to the sides of the anode, and vaporized by induction methods. The application of a negative potential to the cathode will facilitate the depositing of the alkaline earth metal. Barium, for example will form Barium oxide on depositing on the surface of the oxidized

cathode metal. Excess vapor may be removed by pumping from the tube.

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Preparation of Tungsten Wire

THE preparation of tungsten wire with a highly oxidized surface, suitable for vapor deposition, is an interesting process (13). The wire is cleaned at the start by passing it through an oxidizing furnace at 400-500°C., to burn off the organic matter. Other organic impurities may be removed by drawing the wire through molten sodium hydroxide at 300-400°C. The clean wire is passed through an oxidizing furnace at 700°C., and the higher oxides, WO_3 and W_2O_5, are formed. Finally, the wire is led through a pre-heated mixture of hydrogen and steam to reduce the higher oxides to WO_2.

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Activation of Wire Coating

IT is the purpose of the activation procedure to form on the surface of the cathode, whether it is a wire filament or a cathode sleeve, that layer of alkaline earth oxide which will give satisfactory electron emission. A practical discussion of the methods employed in this country for preparing coatings has been presented by L. L. McMaster (14). While this is a subject of interest primarily to radio engineers, reference will be made to the processes insofar as they apply specifically to wire products. The first problem is to break down the alkaline earth metal compounds deposited on the filaments in paste form. Thermal decomposition at 1250° C. during the exhausting of the tube leaves the alkaline earth oxide and a gas, which is removed from the tube by pumping. A high frequency discharge will reduce the alkaline earth compound to the oxide in a neon or argon filled gas discharge tube (15). Further high frequency discharge will activate the Barium oxide coating and lower the work function. In these processes the Barium oxide is further reduced to leave a thin layer of Barium metal on the surface of the Barium oxide. While heat will effect this result, superficial reagents are sometimes introduced into the tube to reduce the oxide. Thus, pure methane is introduced, which decomposes into hydrogen and carbon, the latter reducing the oxide (16). For those processes employing the paste method, a small amount of carbon may be added to the mixture.

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THORIATED tungsten filaments, which are used extensively in medium powered radio tubes, may be activated by heating for one minute at 3000°C., in hydrogen, oxygen, or nitrogen at atmospheric pressure, or at lower temperatures for longer periods of time (17). It will be observed that the activation procedures involve, for the most part, the heating of

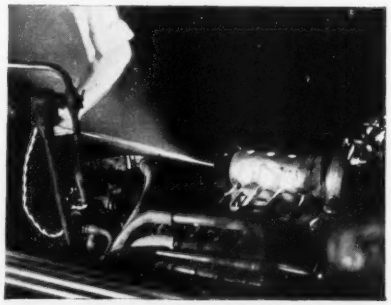

Fig. 4. Swaging of Tungsten Ingots. Courtesy of RCA.

✦ ✦ ✦ ✦

the cathodes to some point above operating temperature. This not only effects the important thermal decompositions, but also causes emission of occluded gases which may be present in the cathode. These extraneous gases are removed from the tube. The gases are also liberated from the anodes, which have been heated by radiation from the cathode.

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Refractory Coatings For Heater Wires

WHEREAS Tungsten and thoriated Tungsten wires are used exclusively for medium and high powered tubes, at high operating voltages, the smaller tubes exclusively use indirectly heated cathodes. As may be seen from Figure 1, the heater wires of the indirectly heated cathodes are surrounded by cathode sleeves, upon which lies the activated coating. There are various methods for insulating the heater wires from the cathode sleeve. If too great an insulation thickness is used, as pointed out before, a long time will be required to bring the emission surface to the operating temperature.

✦ ✦ ✦

A SIMPLE way of insulating the heater wires is to place them in insulating tubes and the space between the heater and the cathode filled with Aluminum Oxide (A12 03) (18). However, it is not easy to secure a very thin insulating coating by this method. By coating the wire with a substance unstable to heat, as wax, paraffin, or lacquer, and further coated with a refractory powder, it is possible to obtain a gas-tight sintered coating on heating to 1600°C. (19). This method is applicable in particular to Tungsten, or Molybdenum wires. It is possible to introduce the alkaline earth metal by these means, as a compound like Barium azide may be mixed with the refractory material, and liberated at high heat (20).

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Metals and Alloys Employed in Tube Wire Parts

TUNGSTEN—For the filament wires of medium and large powered tubes, tungsten wire is outstanding. It was noted that tungsten has the highest melting point of the metals. Though it is not as efficient an emitter as thoriated tungsten, it can give good emissions because of the high temperatures attained. At operating temperature, the tungsten filaments are usually whitish in appearance. The preparation of fused Tungsten metal, discovered 25 years ago, is of historic interest. The metal powder, heated in nickel crucibles, is compressed, after which a heavy electric current fuses the particles into one solid mass. From the tungsten ingot, the rods and wires are drawn, as in

Figure 4. In this illustration an ingot ⅜" square and 16" long is being drawn through a furnace maintained at a temperature of 2000°F. The rod will be drawn 60 times until it has been reduced to a strand of .002" diameter wire.

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IN the long lengths of Tungsten filament, such as in high powered tubes, there are placed wire supports or springs to maintain the tension in the wires. The filament wires are welded to supports and lead-in wires.

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THORIATED - TUNGSTEN.—The addition of .75% to 2.0% thorium oxide to the Tungsten ingot before it is drawn, will appreciably lower the work function. There are other elements that will produce the same results, but not as effectively as thorium. Prolonged heating at high temperatures and high voltages will seriously shorten the life of a thoriated Tungsten filament.

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MOLYBDENUM—Molybdenum rods and wires have been applied to radio vacuum tubes, usually in the grid structures, or else in supports, anchors, or other miscellaneous parts. Wire sizes .0015 to .035" diameter are stocked for radio purposes. The wire is either packed in spools or coils, or else in cut lengths required by the radio tube. Molybdenum will weld readily to other metals as Iron, Copper, or Nickel, but not so easily to itself. The electron emission qualities are inferior to Tungsten, not only with regard to melting point, but also due to the fact that Molybdenum has a higher vapor pressure than Tungsten, rendering the metal not entirely suitable for high temperature operation.

VARIOUS Tungsten - Molybdenum alloys find miscellaneous applications in radio tubes. Others of the following compositions have been applied to grid wires and other tube parts; Molybdenum 15-40; Iron 10-30; and Nickel, at least 40%. The Molybdenum may be partly replaced by Tungsten and the Nickel by Cobalt. Another alloy of Molybdenum, Molybdenum — 20, Nickel — 50; Manganese 2.25; Vanadium—0.3; Carbon 0.1; Silicon 0.2; and the rest Iron, is furnished in wire form for radio tubes. It is annealed at 900-1200°C. (21).

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TANTALUM — Wires of Tantalum or Tantalum-Tungsten alloy are not used to any great extent in radio tubes of this country, though they are more common abroad. The wire is stocked in .001" to .250" size diameter and rods from ⅜" to one inch. Tantalum does not possess the hot strength of Tungsten, and is subject to the same failing of Molybdenum—high vapor pressure. Tantalum does possess, however, a great resistance to corrosive influences. The Tantalum-Tungsten alloys possess an inherent springiness, rendering them suitable for springs.

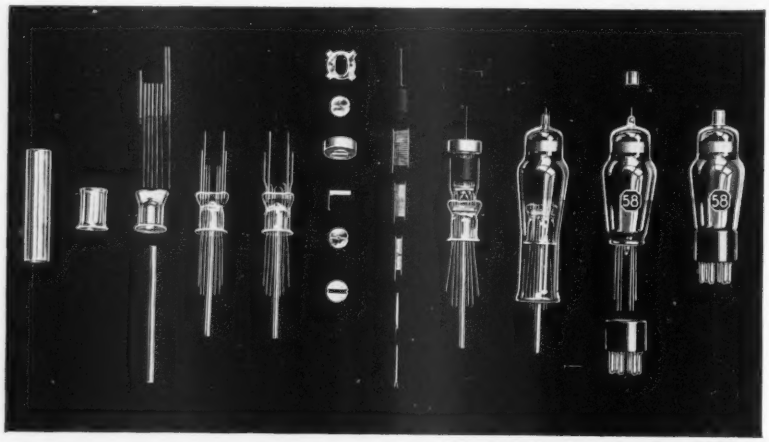

Fig. 5. Vacuum Tube Construction. Courtesy of RCA.

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PLATINUM—Platinum and platinum alloys monopolized the field at one time as the core for oxide coated filaments and lead-in wires. They were superseded by newly developed, less expensive alloys.

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NICKEL — Various nickel and silicon-nickel alloys are available as core materials for oxide-coated filaments. Pure Nickel, because of its ductility, lends itself readily to the formation of woven meshes, such as those used in screen grids. The wires must be of high quality and free from deleterious gases.

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"KONAL"—Konal is an alloy of Nickel-Cobalt-Ferrotitanium (80-20-10) (Reference 22). This alloy was developed to meet objections to nickel filaments and supersede the platinum filaments. It operates 175°C. cooler than Platinum filaments. It is harder to forge than tool steel, but it is non-sputtering at high temperatures, and does not lose its strength very much with increasing temperatures.

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"SVEA" Metal (Iron 99.95%) — A chemically pure iron is available in wire form as a grid material. The freedom from gas inclusions and elements detrimental to tube life have made this material popular in certain applications.

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Grids

THE grid structure of the radio vacuum tubes play an important part in the functioning of the tube. By reason of the potential applied to the grid, a measure of control is expressed on the flow of electrons from the cathode to the anode. To prevent retardation of the electrons, the spacings between the grid wires are relatively large. Close tolerances are necessary, not only on wire size, but also on the

(*Please turn to Page 43*)

1938

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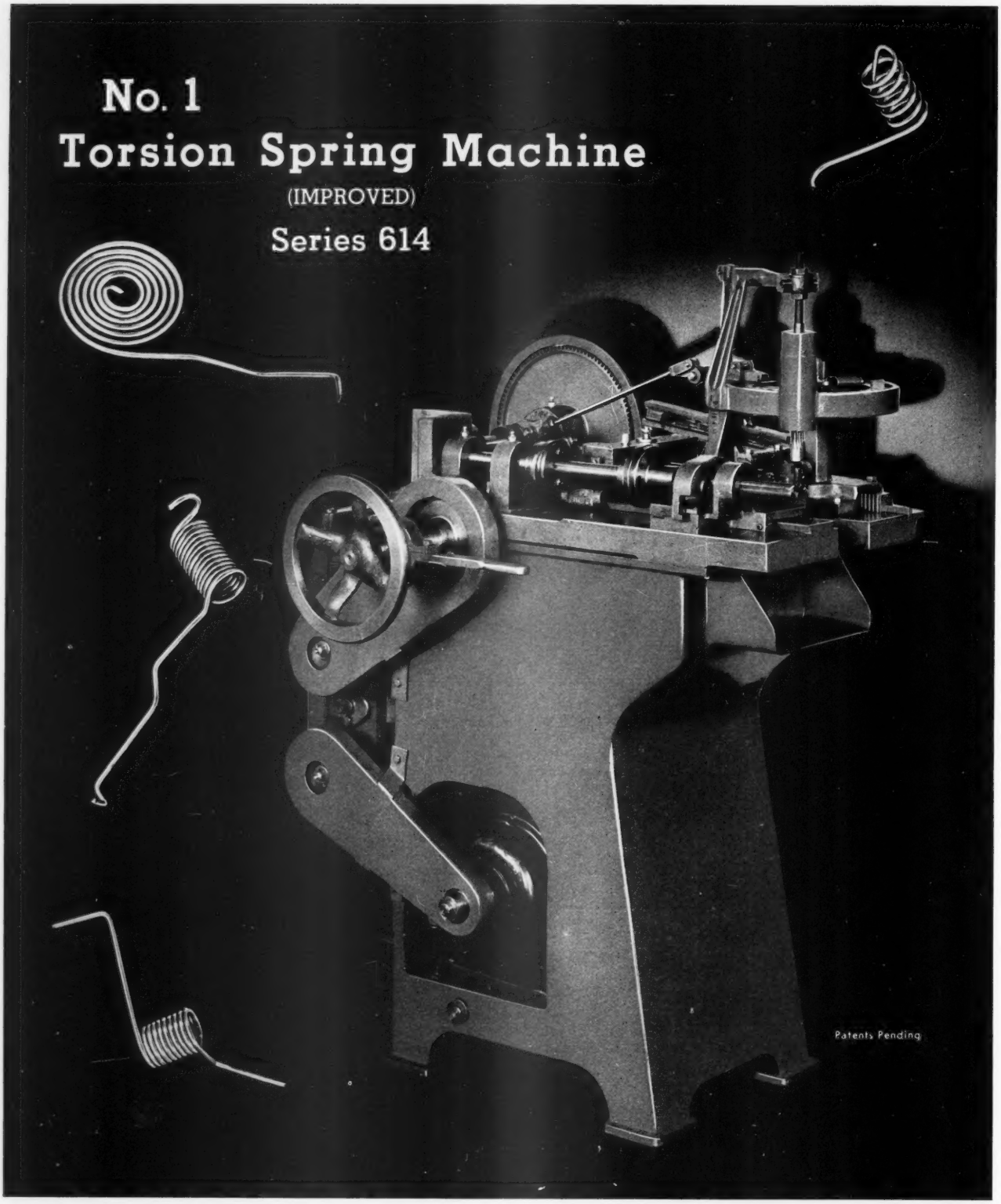

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Vol. 13 JANUARY, 1938 No. 1

Research On Fatigue Properties of Heavy Helical Springs

PART I

By C. T. Edgerton, Chairman,

A. S. M. E. Research Committee On Mechanical Springs

Progress report number three of the sub-committee on heavy helical springs of the Special Research Committee on Mechanical Springs of the American Society of Mechanical Engineers. ✦ ✦ ✦ ✦ ✦

IN two articles published in 1934*, Mr. **J. B. Johnson,** Chief of Material Branch at Wright Field, described some endurance tests on helical springs conducted at the Field under his supervision. The materials represented in the test springs were:

Plain Carbon—Basic Electric Melt.
Plain Carbon — Acid Open Hearth Melt.
Chrome Vanadium—Electric Melt.
Silico-Manganese—Electric Melt.
Beryllium Bronze.

Dimensions on the test springs were:

3.25″ outside diameter
.562″ round bar
4.45″ solid height
7.75″ free height
8 coils
End ground square.

✦ ✦ ✦

IN the endurance tests, which were through a zero maximum stress range, the stress at which springs ran 1,000,000 cycles before failure was taken as the endurance limit. Collateral tests were made on straight pieces of the various materials, in tension and torsion, and standard rotating beam endurance tests were also run. Results of the various tests are summarized in Table I.

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IT will be noted that the plain carbon electric steel showed best results in the endurance tests on springs, although somewhat inferior to the chrome vanadium in the rotating beam tests. This result, as Mr. Johnson pointed out, is probably due to the greater sensitivity of chrome vanadium steel to "stress-raisers".

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ON learning of these tests, your chairman and secretary entered into correspondence with Mr. Johnson, who became interested in the work of the Committee, and offered to conduct further tests on springs which we would furnish. This offer was very welcome, as the experimental program on heavy helical springs has been completely suspended in recent months, owing to business conditions.

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General Test Methods

IN connection with the original series of tests, the Sub-Committee drew up a tentative program covering the major variables to be investigated, — such as chemical composition, heat treatment, size of spring, etc., — and specifying the sizes for test springs, general methods of fabrication and heat treatment, and methods of conducting the calibration tests on the springs and the collateral physical and metallurgical tests on the material. In the work at Wright Field it is proposed to follow this program in most respects, but a few changes have been made. The most important of these changes, having to do with the selection of stresses for the fatigue runs, requires a brief explanation.

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A CRITICAL examination of the logged readings from a number of rotating beam endurance tests indicates that the S-N relation, for ferrous metals, can be represented with satisfactory accuracy by an equation of the form:

$$(N-a)\ (S-b) = K$$

This will be recognized as the equation of a rectangular hyperbola; N=a and S=b are asymptotes to the curve. The value of a is usually negative. The value of b may be interpreted as the endurance limit.

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A MATHEMATICAL investigation has been successful in

*The Iron Age—March, 1934.

developing formulas for the most probable values of a, b, and k, from suitable logged values of S and N. These formulas, while somewhat complex, are not difficult to handle.

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IF the theory just described is sound, a material saving can be effected in the time required to determine an endurance limit, as the probable value can be predicted from a series of test runs in which the values of N range from a few thousand cycles up to a maximum of 1,000,000 to 2,000,000. The range mentioned has been found to give predicted values which agree very closely with direct determinations. There seems to be no good reason why the proposed method would not be equally satisfactory for fatigue tests of large helical compression springs; and the saving in time would be even greater than with rotating beam tests, as a machine suitable for cyclic testing of such springs is necessarily massive, and operates at a relatively slow speed.

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THERE is another practical advantage in a method of endurance testing helical springs which develops a complete S-N curve for the material, rather than merely its endurance limit. The failure of such a spring, in actual service, is not usually a catastrophe, and users of these springs do not necessarily require an article which will last indefinitely. Hence the economic optimum is a spring which will give the longest life per dollar of cost, rather than one which will last forever regardless of cost, and the comparative life at stresses above the endurance limit is of very practical importance.

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THE test springs were therefore designed for fatigue runs at a graduated series of stresses, ranging from the upper limit obtainable down to about the endurance limit. The maximum stress applied in each case was designed to compress the spring through most of its total range of movement. This of course, means that the springs would be cold worked in varying degrees, and it was realized that this cold working would undoubtedly affect the results of the endurance tests. However, the procedure approximately reflects usual design and service conditions; that is, a spring which is expected to withstand a

TABLE I

Fatigue Characteristics of Helical Springs Original Tests at Wright Field, as Reported in the Iron Age of March 15, 1934.

	TYPE OF MATERIAL	Acid Open Hearth	Basic Electric	Chr. Van. Electric	Silico-Man. Electric	Beryllium Bronze
Chemical Composition	Carbon	.91	1.04	.52	.53	
	Manganese	.38	.38	.66	.83	
	Silicon	.16	.16		1.96	Cu=2.38
	Phosphorus	.036	.015			
	Sulphur	.037	.018			Be=97.60
	Chromium			.88		
	Vanadium			.21		
Heat Treatment	Coiling Temperature	1700°F.	Cold	Hot	Hot	Cold
	Hardening Temperature	1575°F.	1550°F.	1600°F.	1600°F.	Heated 520°F. for 2 hours after coiling
	Hardening Time		20 min.	40 min.	40 min.	
	Quench in	Oil	Oil 120°F.	Oil 130°F.	Oil 130°F.	
	Draw Temperature	940°F.	800°F.	810°F.	860°F.	
	Draw Time	Lead—1 min.	Lead—15 min.	1 hour	1 hour	
	Quench from draw in	Air	Air	Air	Air	
Physical Properties in Tension	Proportional Limit (1)	144000	144000	140000	132000	110000
	Yield Point (2)	179000	194000	229000	210000	132000
	Ultimate Tensile Strength	225000	237000	237000	236000	166000
	Elongation in 2"	2%	5%	11%	12%	5%
	Modulus of Elasticity	30200000	29800000	30200000	29100000	18200000
	Ratio—Yield Pt./Ult. Tens. Str.	.80	.83	.96	.89	.83
Physical Properties in Torsion	Yield Strength	118000	126000	141000	141000	95000
	Modulus of Rupture	173000	194000	183000	190000	110000
	Torsional Modulus	10800000	10800000	11200000	10700000	6500000
	Ratio—Yield Str./Mod. of Rupture	.68	.64	.73	.74	.86
Hardness	Brinell—3000 Kg.	438-450	430-470	477-488	438-457	303
Rotating Beam Fatigue Tests	Fatigue Limit	80000	98000	104000	112000	30000 (3)
	Same with 60° V notch	36000	48000	28000	35000	16000 (3)
	Ratio—Fat. Lim./Ult. Tens. Str.	.36	.41	.44	.48	.18
	Ratio—Fat. Lim. with notch/Fat. Lim. Std.	.45	.49	.27	.31	.53
Torsion Fatigue Tests	Fatigue Limit, 0—max. (4)	102000	123000	128000	138000	30000
	Same—reversed stress (4)	52000		75000		16000
	Same—Springs, 0—max. (5)	73000	98000	82000	75000	37000
	Ratio—Fat. Lim. Tors./Fat. Lim. Bend	.65		.72		.53

(1) .0001 per inch. (2) .002" per inch on Acid O.H. and Basic Electric; .001" per inch on others. (3) 300000000 cycles. (4) Polished Straight Specimens. (5) 1000000 cycles.

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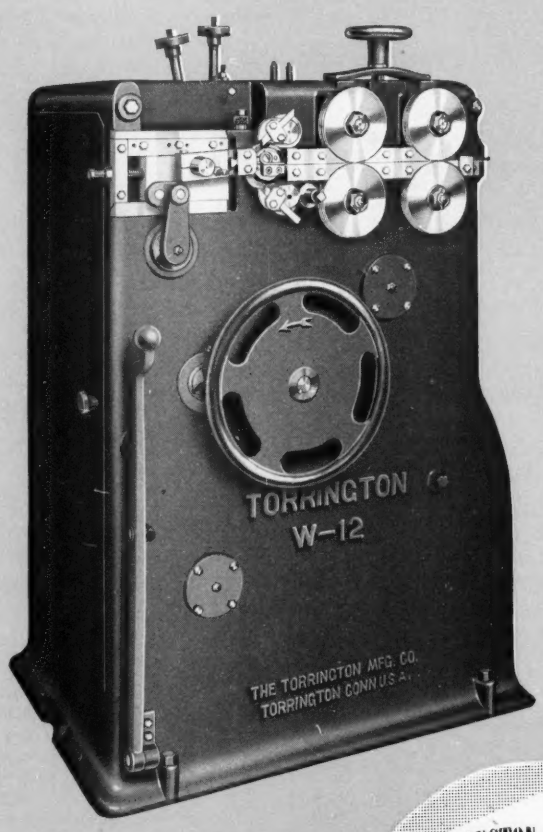

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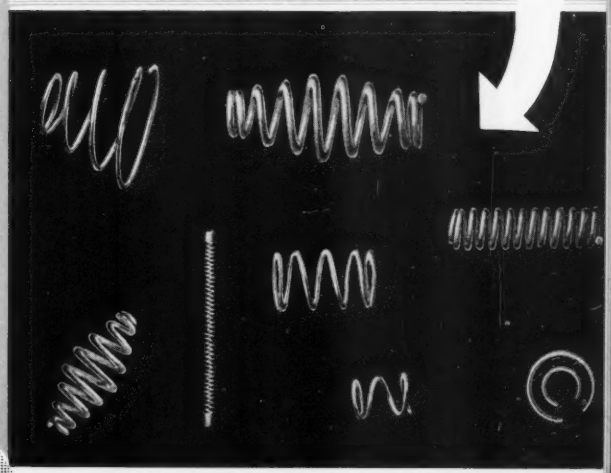

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given maximum stress in service is in general designed to go solid at a stress somewhat above this service maximum.

✦ ✦ ✦

ANOTHER change in the program was made necessary by the limited capacity of the cyclic testing machine at Wright Field. The standard size of test spring originally adopted was 1″ round bar and 5″ mean helix diameter; this was amended to ¾″ round bar and 3¾″ mean diameter, the spring index thus being the same as before.

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Grades of Material to be Tested

FOR the first runs springs will be made of:

(a) Plain Carbon, Open Hearth Basic Melt. This is the material in most general use for large helical springs, and is therefore a logical point of departure for the project.

(b) Plain Carbon, Electric Melt. This grade gave the best endurance limit in the tests reported by Mr. Johnson, and it will be desirable to check the results on steel of known history, hardenability characteristics, etc.

(c) Silicon Vanadium, Electric Melt. This steel was originally developed to solve the problem of producing Pullman equalizer springs of increase flexibility, with no increase in overall dimensions. Results have been very satisfactory, and the industry is deeply interested in the possibilities of this steel.

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OTHER grades will be selected and announced later.

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Calculation of Fibre Stresses—The Rover-Wahl Correction

IN calculating fibre stresses from the results of the calibration tests, and in assignment of stresses for the endurance tests, it is proposed to use the Rover-Wahl formula. There seems to be no doubt that this formula states, with approximate accuracy, the maximum stress in a helical spring of given dimensions. But some members of the Committee have questioned the necessity of considering this maximum as the critical design stress. Mr. Wahl himself has referred to this point as something that remains to be proven. The application of the Rover-Wahl correction to the design of certain springs, long standard in railroad service, results in stresses that are so high as to appear quite impossible, in view of the uniformly good service record of these designs. Finally, it would appear from Dr. McAdam's recent work that, in the case of stress augments due to notches or other discontinuities, the reduction in fatigue limit seldom or never corresponds to the theoretical intensity of the augmented stress. It seems reasonable to expect that the same thing would be true for stress augments due to "form factor".

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THE logical line of attack on this problem is to run comparative fatigue tests in springs of varying index, but otherwise as nearly identical as possible. In view of the great importance of this problem, it is proposed to make such a comparative test as early in the program as possible.

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COLLATERAL Tests and Metallurgical Investigations: Tensile and other tests on straight bars, treated with the springs, as well as micro-examination of the steel, will be conducted, in general accordance with the tentative program. Mr. Johnson has undertaken to test the springs with a magnaflux apparatus, before the fatigue runs.

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FURTHER Development of the Program: Reporting of Results. The program as so far developed contemplates (a) determination of the available spring material which, made into helical springs from bars with "as rolled" finish, will develop the best endurance limit; (b) using springs of the grade so selected, to run tests for the comparative effect of various surface finishes (cold drawing, centreless grinding, etc.) Further steps will be decided on and announced later.

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EACH group of springs will be designated by a series letter (Series A, Series B, etc.) and the results of tests on each series will be presented in a separate section of this report, to be issued as soon as work on the series is completed and results analyzed.

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Fatigue Tests on Series "A" Springs of Plain Carbon Basic O. H.

Section II

MATERIAL used was basic open hearth heat No. 44355, of Pittsburgh Crucible Steel Company, Chemical composition:

Carbon	**1.05 %**
Manganese	**.36 %**
Phosphorus	**.020%**
Sulphur	**.032%**
Silicon	**.15 %**

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THREE-QUARTER inch round spring bars were rolled and sheared to 83½″ long, tapered on both ends, and fabricated into springs in "as rolled" condition and surface finish. The springs were coiled hot, to graduated heights ranging from 12″ for spring A-1 down to 7 29/32″ for A-9. The corresponding range of pitch measurements was from 2″ to 1.21″. Approximate mean helix diameter was 3¾″, to give a spring index of 5. The springs after coiling were cooled in air.

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Heat Treatment

SPRINGS were reheated to a temperature of 1620°F. in a natural-gas fired furnace, and quenched in oil; then drawn for one hour (at temperature) in a lead bath at 700°F. and air cooled. Brinell Hardness measurements on the finished springs ranged from 415 to 444.

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Calibration Tests

THE springs were first compressed solid several times in a hydraulic spring tester, with the following results:

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Spring No.	Coiled Height	Times Solid	Free Hgt. after Test
A-1	12 ″	5	9 1/16″
A-2	11 23/64″	5	8 27/32″
A-3	10 27/64″	5	8 25/32″
A-4	9 41/64″	6	8 39/64″
A-5	9 43/64″	6	8 39/64″
A-6	9 5/8″	6	8 33/64″
A-7	7 29/32″	6	7 21/32″
A-8	7 55/64″	6	7 37/64″
A-9	7 29/32″	6	7 41/64″

The ends of the springs were then ground square on a Gardner Disc grinder.

THE calibration tests were conducted in accordance with the Tentative Program proposed some time ago by the Sub-Committee. The complete test data are given in Table II. In addition to the overall heights measurements at graduated loads, measurements were taken from prick punch marks spanning four active coils, on springs A-1, A-3, and A-9 only. The latter measurements will be used to calculate working values of the torsional modulus and of the number of inactive coils; and an analysis of the figures and results will be communicated in a later report.

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SPRINGS were then forwarded to Wright Field for the fatigue tests, together with six straight pieces of the material; the latter had been heat treated along with the springs, and were intended for tension and torsion tests.

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AT Wright Field the springs were first compressed solid several times, and the height measured after each compression. Tests with a magnaflux apparatus indicated no cracks or other defects. They were then run successively through the endurance

Springs Series A. TABLE II Calibration Tests

Loads in Pounds	Overall Heights Compression Front	Compression Back	Compression Average	Release Front	Release Back	Release Average	Loads in Pounds	Compression Front	Compression Back	Compression Average	Release Front	Release Back	Release Average
	Spring A-1							Spring A-2					
Free	8.751	8.947	8.849	8.696	8.891	8.794	Free	8.758	8.731	8.745	8.706	8.670	8.688
500	8.490	8.510	8.500	8.346	8.360	8.353	500	8.364	8.375	8.370	8.210	8.233	8.222
1000	8.120	8.114	8.117	7.882	7.878	7.880	1000	7.977	7.978	7.978	7.776	7.782	7.779
1500	7.738	7.723	7.731	7.457	7.446	7.452	1500	7.628	7.622	7.625	7.334	7.331	7.333
2000	7.353	7.339	7.346	7.007	6.990	7.003	2000	7.210	7.205	7.208	6.922	6.919	6.921
2500	6.952	6.938	6.945	6.627	6.616	6.622	2500	6.834	6.830	6.832	6.530	6.527	6.529
3000	6.532	6.520	6.526	6.229	6.218	6.224	3000	6.429	6.425	6.427	6.179	6.177	6.178
3500	6.120	6.108	6.114	5.854	5.854	5.849	3500	5.984	5.980	5.982	5.783	5.781	5.782
4000	5.666	5.654	5.660	5.473	5.463	5.468	4000	5.545	5.541	5.543	5.431	5.430	5.431
4500	5.227	5.214	5.221										
Solid	5.126	5.121	5.124				Solid	5.167	5.171	5.169			
	Spring A-3							Spring A-4					
Free	8.649	8.601	8.625	8.618	8.542	8.580	Free	8.436	8.453	8.445	8.396	8.412	8.404
500	8.251	8.262	8.257	8.149	8.169	8.159	500	8.041	8.051	8.046	7.964	7.987	7.976
1000	7.867	7.871	7.869	7.718	7.725	7.722	1000	7.691	7.696	7.694	7.555	7.563	7.559
1500	7.487	7.884	7.486	7.298	7.292	7.295	1500	7.290	7.287	7.289	7.141	7.141	7.141
2000	7.097	7.093	7.097	6.880	6.877	6.879	2000	6.976	6.976	6.976	6.790	6.790	6.790
2500	6.710	6.706	6.708	6.502	6.500	6.501	2500	6.569	6.568	6.569	6.397	6.397	6.397
3000	6.317	6.314	6.316	6.116	6.114	6.115	3000	6.200	6.200	6.200	6.037	6.036	6.037
3500	5.908	5.906	5.907	5.744	5.742	5.743	3500	5.820	5.821	5.821	5.689	5.687	5.688
4000	5.507	5.504	5.506	5.372	5.370	5.371	4000	5.414	5.415	5.415	5.343	5.343	5.343
Solid	5.057	5.059	5.058				Solid	5.126	5.127	5.127			
	Spring A-5							Spring A-6					
Free	8.432	8.453	8.443	8.348	8.414	8.381	Free	8.304	8.315	8.310	8.275	8.275	8.275
500	8.092	8.102	8.097	7.982	8.001	7.992	500	7.926	7.936	7.931	7.853	7.870	7.862
1000	7.738	7.743	7.741	7.579	7.588	7.584	1000	7.595	7.599	7.597	7.496	7.506	7.501
1500	7.366	7.361	7.364	7.163	7.163	7.163	1500	7.226	7.224	7.225	7.058	7.055	7.057
2000	6.987	6.983	6.985	6.805	6.804	6.805	2000	6.860	6.856	6.858	6.675	6.671	6.693
2500	6.606	6.602	6.604	6.427	6.426	6.427	2500	6.453	6.449	6.451	6.307	6.305	6.306
3000	6.213	6.210	6.212	6.050	6.048	6.049	3000	6.047	6.043	6.045	5.922	5.920	5.921
3500	5.827	5.824	5.826	5.703	5.701	5.702	3500	5.643	5.640	5.642	5.552	5.550	5.551
4000	5.430	5.427	5.429	5.357	5.358	5.358							
Solid	5.159	5.147	5.153				Solid	5.120	5.120	5.122			
	Spring A-7							Spring A-8					
Free	7.520	7.436	7.478	7.512	7.418	7.465	Free	7.486	7.485	7.486	7.476	7.469	7.473
500	7.081	7.096	7.089	7.092	7.113	7.103	500	7.144	7.164	7.154	7.112	7.134	7.123
1000	6.774	6.785	6.780	6.753	6.766	6.760	1000	6.800	6.811	6.806	6.772	6.781	6.777
1500	6.423	6.425	6.424	6.379	6.381	6.380	1500	6.458	6.460	6.459	6.418	6.419	6.419
2000	6.058	6.058	6.058	6.027	6.026	6.027	2000	6.126	6.128	6.127	6.084	6.086	6.085
2500	5.703	5.701	5.702	5.686	5.685	5.686	2500	5.793	5.795	5.794	5.763	5.766	5.765
3000	5.354	5.353	5.354	5.338	5.338	5.338	3000	5.474	5.476	5.475	5.459	5.462	5.461
Solid	5.096	5.104	5.100				Solid	5.145	5.154	5.150			
							Spring A-9						
Free	7.547	7.480	7.514	7.537	7.467	7.502	2000	6.139	6.139	6.139	6.112	6.111	6.112
500	7.187	7.203	7.195	7.147	7.164	7.156	2500	5.805	5.804	5.805	5.777	5.776	5.777
1000	6.835	6.842	6.839	6.808	6.812	6.810	3000	5.495	5.495	5.495	5.490	5.489	5.490
1500	6.484	6.484	6.484	6.457	6.456	6.457	Solid	5.222	5.226	5.224			

TABLE II

Deflection Readings on Four Active Coils.

Loads in Pounds	Spring A-1		Spring A-3		Spring A-9	
	Compression	Release	Compression	Release	Compression	Release
Free	5.65	5.60	5.63	5.61	4.74	4.72
500	5.48	5.34	5.40	5.31	4.54	4.48
1000	5.24	5.03	5.13	5.02	4.30	4.27
1500	4.97	4.76	4.88	4.73	4.06	4.03
2000	4.72	4.46	4.63	4.49	3.81	3.80
2500	4.49	4.21	4.40	4.21	3.60	3.58
3000	4.19	3 95	4.14	3.94	3.39	3.38
3500	3.90	3.68	3.86	3.70		
4000	3.61	3.44	3.54	3.40		
4500	3.30					
Solid	3.09		3.12		3.15	

Spring Measurements and Development of Constants

Spring No.	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9
Size of Bar (1)	.736″	.737″	.729″	.728″	.733″	.731″	.731″	.735″	.738″
Outside Diameter (2)	4.581″	4.576″	4.555″	4.546″	4.534″	4.533″	4.498″	4.516″	4.511″
Mean Helix Diameter (3)	3.781″	3.778″	3.761″	3.753″	3.743″	3.746″	3.723″	3.737″	3.727″
Spring Index (4)	5.137	5.130	5.159	5.155	5.106	5.124	5.093	5.088	5.050
Rover-Wahl Correction Factor	1.3010	1.3015	1.2995	1.2998	1.3031	1.3019	1.3040	1.3044	1.3070
M.F.S. per 100-lb Ld. — Conventional Form'la	24149	24082	24722	24772	24204	24422	24272	24013	23615
M.F.S. per 100-lb Ld. — with Rover-Wahl Cor.	31418	31343	32126	32199	31540	31795	31651	31323	30865
Capacity Solid—lbs.	4570	4410	4550	4330	4350	4140	3355	3480	3415
M.F.S. Solid — Conventional Form'la	110360	106200	112485	107260	105290	101107	81430	83565	80645
M.F.S. Solid — with Rover-Wahl Cor.	143580	138220	146170	139420	137200	131630	106190	109000	105400

(1) Average of six measurements.
(2) Average of six measurements, not corrected for pitch angle.
(3) Corrected for pitch angle (perpendicular to helical axis).
(4) Ratio—Mean Helix Diameter/Size of Bar.

test. Measurements, loads and stresses, and test results are summarized in Table III. The endurance tests were conducted in a cyclic testing machine of about 9000 pounds capacity and 3¼″ maximum travel, running at 60 revolutions per minute. A photograph of the machine is on file with the Sub-Committee.

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RESULTS of the tension and torsion tests were as follows:

In Tension
Proportion Limit 118,000
Yield Strength (.002″/in.) 142,300
Ultimate Tens. Strength 206,200
Elongation 7%
Ration—Yield Pt./U. T. S. .69
Modulus of Elasticity 29.1×10^6
In Torsion
Proportional Limit 82,500
Yield Pt. (.002″-/in.) 119,000
Modulus of Rupt. 153,100
Ratio—Yield Pt./-Mod. Rupt. .78
Torsional Modulus 11.8×10^6

THE tests at Wright Field are described in Air Corps Memorandum Report M-56-2783 Part II, a copy of which has been furnished to the Sub-Committee by Mr. Johnson.

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AS proposed in Section I of the present report, an analysis of the results of the endurance test was made for the equation representing the probable stress-endurance curve, based on the assumption that this equation would be of the form:

$$(N-a)\ (S-b) = K$$

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THE probable equation was found to be:

$$(N-26.84)\ (S-72.73) = 3414.13$$

in which both S and N are in thousands. Figure I shows a graphical plot of the equation, together with the actual test observations.

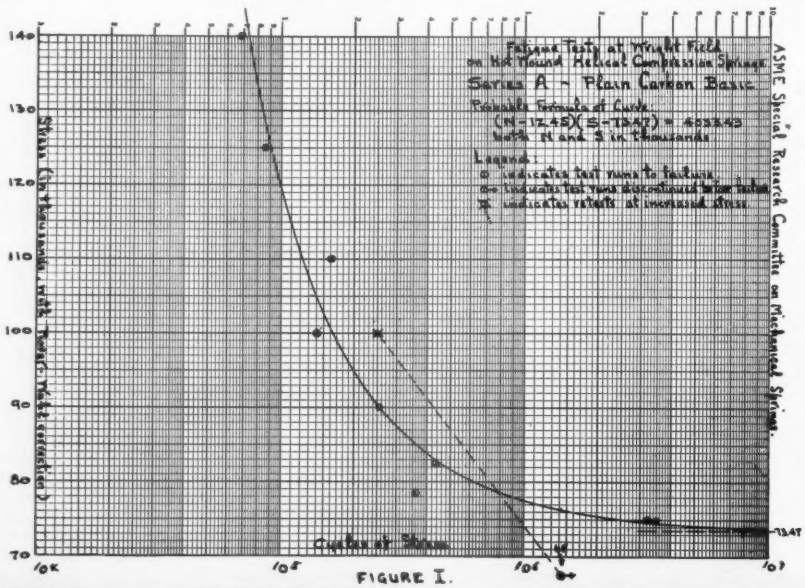

FIGURE I.

THE analysis for the probable equation included, of course, only the readings on tests that ran to destruction; that is, on springs A-1 to A-7 inclusive. The results for all seven springs plot fairly close to the

TABLE III

Series A Springs — Set in Inches

Spring No.	Free Height	Solid Height	Total Deflection	Ratio Deflection Solid Hgt.	Satic Loading Compression No. 1	Satic Loading Compression No. 2	Satic Loading Compression No. 3	Fatigue Loading No. of Cycles 6000	Fatigue Loading No. of Cycles 10000	Total Set	Load in lbs. used in Fatigue Test	Stresses Rover Wahl Formula	Number Cycles to Failure
1	8.73	5.16	3.57	.69	.05	.06	.00	.12	.00	.23	4460	140000	68500
2	8.68	5.19	3.49	.67	.06	.02	.02	.00	.00	.10	2507	78500	363400
3	8.56	5.06	3.50	.69	.05	.02	.02	.01	.00	.10	3890	125000	86400
4	8.37	5.13	3.24	.63	.05	.02	.01	.00	.00	.08	3416	110000	161000
5	8.35	5.21	3.14	.60	.06	.02	.03	.01	.00	.11	3178	100000	140700
6	8.25	5.16	3.09	.60	.05	.03	.01	.00	.00	.09	2835	90000	254000
7	7.44	5.14	2.30	.45	.05	.01	.00	.00	.00	.06	2615	82500	437600
8	7.46	5.18	2.28	.44	.02	.00	.00	.00	.00	.02	2408	75000	3228400 No failure
9	7.48	5.26	2.22	.42	.02	.00	.00	.00	.00	.02	2117	65000	1437300 No failure
9 (retest)	7.46	5.26	2.20	.42							3258	100000	250200 Retest

Brinell Hardness taken on flats cut from springs—441 to 460.

curve. The agreement, in fact, is markedly better than is usually found in the case of a series of rotating beam endurance tests. In the writer's opinion, this improved correlation is to be expected; relative stresses in helical springs can be measured with greater accuracy than those in a rotating beam specimen.

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RESULTS from springs A-8 and A-9, while excluded from the analysis for the probable S-N curve, both furnish contributory evidence of its approximate accuracy. The correlation of the A-8 result with the curve is obvious. Spring A-9 was tested at 65,000 fibre stress, and ran nearly 1,500,000 cycles, without failure. It was later tested at a stress of 100,000, and failed at 250,000 cycles. This is a longer life than is predicted by the probable curve. Now current fatigue theory states that cold working at a stress lower than the endurance limit raises that limit. The original run on Spring A-9 was at 65,000 psi, less than the endurance limit; consequently the life of the spring was markedly increased.

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COMING now to a comparison of the results with those of the original tests at Wright Field, as summarized in Section I of this report; it must be borne in mind that in these tests the fatigue limit of the springs was taken as the stress at which they would run 1,000,000 cycles. The true fatigue limit is about 5,000 psi less. With this correction, the original tests show the following fatigue values:

For Basic Electric	**93,000 psi**
For Chrome Vanadium	**77,000 psi**
For Silico-Manganese	**70,000 psi**
For Acid Open Hearth	**68,000 psi**

Thus the Basic Open Hearth Springs of Series A, with a probable endurance limit of 72730 psi, rate somewhat better than acid open hearth and silico-manganese steels, somewhat lower than chrome vanadium, and very much lower than basic electric.

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FURTHER study of the test data brings out these interesting points:

(a) The springs in the original tests were made from centreless ground bars, while Series A springs were fabricated from bars "as rolled". It would appear that the centreless grinding had no consistently beneficial effect on the fatigue results.

(b) The basic electric springs were coiled cold; all other grades, including the Series A springs, were coiled hot. Examination of a straight piece of the basic electric steel led to the belief that it had been cold drawn; and cold coiled springs are quite apt to be fabricated from cold drawn steel. Obviously, this suggests the possibility that a cold drawn finish and/or cold coiling of the springs had a good deal to do with the superior fatigue results obtained from the basic electric. As set forth in Section I of this report, the proposed development of the test program will include an investigation of the effect of various surface finishes.

(c) A comparison of the physical values of the various steels in tension and torsion discloses some interesting and rather puzzling facts. The figures are recapituated for ready reference in Table A.

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EXAMINATION of these figures indicates little or no correlation between the physical and endurance values. Best physical values were shown by the silico-manganese springs, the lowest group but one in fatigue value. Series A, the lowest in physical values, compared favorably in fatigue values with all the other steels except the basic electric.

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IN this connection, attention is invited to the heat treatment of the various groups, and particularly to the draw temperatures, time, and media. The acid springs were drawn at an unusually high temperature, but for only one minute; and while lead may be a faster acting draw medium than air, a draw of this duration can have only a superficial effect. The treatment of the basic electric, chrome vanadium, and silico-manganese steels were conventional. That of the Series A springs was

TABLE A

		Acid Open Hearth	Basic Electric	Chrome Vanadium	Silico Manganese	Basic O.H. Series A
In Tension	Proportional Limit	144000	144000	140000	132000	118000
	Yield Point	179000	194000	229000	210000	142000
	Ulitmate Tens. Str.	225000	227000	237000	236000	206000
In Torsion	Yield Strength	118000	126000	141000	141000	119000
	Modulus of Rupt.	173000	194000	183000	190000	153000
Fatigue Limit of Springs		68000	93000	77000	70000	72730
Ratios	Springs/U. T. S.	.30	.41	.325	30.	.35
	Springs/Mod. Rupt.	.39	.48	.42	.37	.48
Brinell Hardness		438-450	430-470	477-488	437-457	415-444
Draw Temperature		940°F.	800°F.	810°F.	860°F.	700°F.
Draw Time and Medium		Lead—1 min.	Lead—15 min.	1 hour	1 hour	Lead—1 hour

at a rather low temperature (700°F.) and an unusually long time (one hour at temperature, in lead).

THE theory has recently been advanced that this particular draw practise will have a favorable effect on endurance, as the long time draw will effectively relieve internal strains, while the comparatively low temperature will not unduly lower the ultimate

Springs Series B. TABLE IV Calibration Tests

Loads in Pounds	Overall Heights Compression Front	Compression Back	Compression Average	Release Front	Release Back	Release Average	Loads in Pounds	Overall Heights Compression Front	Compression Back	Compression Average	Release Front	Release Back	Release Average
	Spring B-1							Spring B-2					
Free	6.542	6.606	6.574	6.523	6.586	6.555	Free	6.508	6.528	6.518	6.481	6.511	6.496
1000	6.400	6.390	6.395	6.325	6.321	6.323	1000	6.340	6.340	6.340	6.269	6.272	6.271
2000	6.241	6.226	6.234	6.125	6.115	6.120	2000	6.180	6.174	6.177	6.070	6.065	6.068
3000	6.062	6.050	6.056	5.925	5.915	5.920	3000	6.010	6.005	6.008	5.902	5.898	5.900
4000	5.898	5.887	5.893	5.749	5.738	5.744	4000	5.842	5.838	5.840	5.724	5.720	5.722
5000	5.714	5.702	5.708	5.578	5.567	5.573	5000	5.659	5.655	5.657	5.542	5.538	5.540
6000	5.522	5.511	5.517	5.417	5.407	5.412	6000	5.473	5.469	5.471	5.403	5.400	5.402
7000	5.316	5.305	5.311	5.260	5.250	5.255							
Solid	5.088	5.081	5.085				Solid	5.147	5.143	5.145			
	Spring B-3							Spring B-4					
Free	6.427	6.391	6.409	6.410	6.360	6.385	Free	6.098	6.038	6.068	6.088	6.034	6.061
1000	6.208	6.210	6.209	6.172	6.177	6.175	1000	5.883	5.877	5.880	5.858	5.860	5.859
2000	6.060	6.055	6.058	6.003	5.998	6.001	2000	5.739	5.730	5.735	5.690	5.688	5.689
3000	5.892	5.885	5.889	5.812	5.807	5.810	3000	5.581	5.574	5.578	5.539	5.535	5.537
4000	5.732	5.726	5.729	5.637	5.628	5.633	4000	5.400	5.396	5.398	5.369	5.365	5.367
5000	5.553	5.548	5.551	5.481	5.478	5.480							
6000	5.381	5.376	5.379	5.331	5.327	5.329							
Solid	5.075	5.069	5.072				Solid	4.956	4.958	4.957			
	Spring B-5							Spring B-6					
Free	6.220	6.152	6.186	6.215	6.141	6.178	Free	6.172	6.183	6.178	6.158	6.182	6.170
1000	6.019	6.015	6.017	5.988	5.988	5.988	1000	5.911	5.907	5.909	5.981	5.986	5.984
2000	5.863	5.856	5.860	5.813	5.809	5.811	2000	5.861	5.857	5.859	5.808	5.804	5.806
3000	5.707	5.702	5.705	5.645	5.640	5.643	3000	5.704	5.702	5.703	5.653	5.649	5.651
4000	5.541	5.535	5.538	5.488	5.483	5.486	4000	5.548	5.544	5.546	5.500	5.496	5.498
5000	5.379	5.375	5.377	5.332	5.325	5.329	5000	5.385	5.380	5.383	5.338	5.336	5.337
Solid	5.037	5.036	5.037				Solid	5.077	5.078	5.078			
	Spring B-7							Spring B-8					
Free	6.064	6.055	6.060	6.058	6.048	6.053	Free	5.982	6.057	6.020	5.972	6.046	6.009
1000	5.888	5.893	5.891	5.880	5.888	5.884	1000	5.862	5.865	5.864	5.840	5.843	5.842
2000	5.738	5.736	5.737	5.712	5.708	5.710	2000	5.698	5.691	5.695	5.669	5.663	5.666
3000	5.585	5.580	5.583	5.555	5.551	5.553	3000	5.540	5.534	5.537	5.504	5.496	5.500
4000	5.430	5.425	5.428	5.401	5.397	5.399	4000	5.376	5.370	5.373	5.341	5.334	5.338
Solid	5.056	5.052	5.054				Solid	5.005	4.996	5.001			
	Spring B-9												
Free	6.002	5.987	5.995	5.988	5.981	5.985							
1000	5.820	5.823	5.822	5.806	5.810	5.808							
2000	5.674	5.668	5.671	5.651	5.647	5.649							
3000	5.514	5.508	5.511	5.493	5.487	5.490							
4000	5.353	5.347	5.350	5.345	5.339	5.342							
Solid	5.000	4.996	4.998										

Deflection Readings on Four Active Coils

Loads in Pounds	Spring B-1 Compression	Spring B-1 Release	Spring B-3 Compression	Spring B-3 Release	Spring B-9 Compression	Spring B-9 Release
Free	4.10	4.09	3.90	3.89	3.57	3.57
1000	4.01	3.96	3.78	3.75	3.49	3.46
2000	3.90	3.83	3.66	3.60	3.40	3.37
3000	3.78	3.69	3.56	3.47	3.28	3.26
4000	3.69	3.59	3.45	3.38	3.20	3.18
5000	3.57	3.48	3.33	3.30		
6000	3.47	3.36	3.21	3.17		
7000	3.33	3.26				
Solid	3.16		3.00		2.94	

Spring Measurements and Development of Constants

Spring No.	B-1	B-2	B-3	B-4	B-5	B-6	B-7	B-8	B-9
Size of Bar (1)	.746″	.730″	.736″	.732″	.732″	.739″	.732″	.723″	729″
Outside Diameter (2)	3.036″	3.030″	3.018″	3.039″	3.035″	3.032″	3.027″	3.005″	3.018″
Mean Helix Diameter (3)	2.232″	2.245″	2.230″	2.263″	2.257″	2.247″	2.251″	2.238″	2.246″
Spring Index (4)	2.992	3.075	3.030	3.092	3.083	3.041	3.077	3.095	3.083
Rover-Wahl Correction Factor	1.5820	1.5614	1.5725	1.5574	1.5596	1.5697	1.5610	1.5567	1.5596
M.F.S. per 1000-lb. ld. Conventional Form'la	13689	14696	14.243	14693	14654	14177	14645	15081	14794
M.F.S. per 1000-lb. ld. with Rover-Wahl Cor.	21656	22946	22397	22883	22854	22254	22861	23467	23073
Capacity Solid—lbs.	8030	7680	7720	6480	7050	6870	6420	6295	6170
M.F.S. Solid Conventional Form'la	109920	112865	109960	95210	103310	97400	94020	94935	91280
M.F.S. Solid with Rover-Wahl Cor.	173900	176225	172900	148280	161120	152885	146770	147790	142360

(1) Average of six measurements.
(2) Average of six measurements, not corrected for pitch angle.
(3) Corrected for pitch angle (perpendicular to helical axis).
(4) Ratio—Means Helix Diameter/Size of Bar.

strength, of which the fatigue value is supposed to be a function. The results hardly seem to substantiate this theory, although it is true that the values of the two ratios:

$$\frac{\text{Spring Fatigue Limit}}{\text{Ultimate Tens. Strength}}$$

and

$$\frac{\text{Spring Fatigue Limit}}{\text{Torsional Mod. of Rupt.}}$$

for Series A springs are higher than for any of the other grades except the basic electric.

✦ ✦ ✦

OBVIOUSLY further research on these points will be very much in order. They will be commented on further as the program develops and results on other grades and processing methods are available.

✦ ✦ ✦

Fatigue Tests on Series "B" Springs of Plain Carbon Basic O. H. Section III

THE tests on this series were planned to develop some experimental evidence on the applicability of the Rover-Wahl stress correction as the critical design stress. This important problem was described briefly in Section I of this report, and it was there pointed out that a logical approach to the problem would be through fatigue tests on two series of springs, substantially identical in all respects except the spring index. Accordingly, Series "B" springs were fabricated from the same material as series "A", spring bars for the two groups being sheared practically at random from the same rolling. The Series "B" bars were cut 50¼″ long. Approximate mean helix diameter was 2¼″, giving a spring index of 3, as compared with 5 for Series "A". Both groups have approximately 7½ total coils. Coiled heights for Series "B" ranged from 8 1/64″ down to 6 13/32″. Heat treatment was the same as for Series "A".

✦ ✦ ✦

Calibration Tests

THE springs were first compressed solid several times in a hydraulic spring tester, with the following results:

Spring No.	Coiled Height	Times Solid	Free Hgt. After Test
B-1	8 1/64″	5	6 49/64″
B-2	7 9/16″	5	6 45/64″
B-3	7 3/16″	5	6 39/64″
B-4	6 47/64″	6	6 19/64″
B-5	6 25/32″	6	6 13/32″
B-6	6 3/4″	6	6 3/8″
B-7	6 27/64″	6	6 13/64″
B-8	6 7/16″	6	6 7/32″
B-9	6 13/32″	6	6 15/64″

Ends of the springs were then ground square in a Gardner Disc grinder.

✦ ✦ ✦

THE calibration tests paralleled those on Series "A". Complete test data are given in Table IV. Measurements were taken on prick punch marks, spanning four active coils, on springs B-1, B-3, and B-9. The springs were forwarded to Wright Field for the fatigue tests.

✦ ✦ ✦

AGAIN, at Wright Field, the test procedure was substantially identical with that on Series "A". Measurements and test results are shown in Table V. Tests with a magnaflux apparatus indicated no cracks or other defects. Results of tensile and torsion tests, reported in Section II, are of course representative of Series "B" as well as Series "A".

✦ ✦ ✦

TESTS at Wright Field are described in Air Corps Memorandum Report M-56-2783 Part III, a copy of which has been furnished to the Sub-Committee by Mr. Johnson.

✦ ✦ ✦

AN analysis was made for the probable S-N equation cor-

TABLE V

SPRINGS SERIES B — TESTS AT WRIGHT FIELD

Spring No.	Measurements: Free Height	Measurements: Solid Height	Measurements: Total Deflection	Measurements: Ratio Deflection / Solid Height	Set in Inches: Static Loading No. Compressions: 1.	2.	3.	Set in Inches: Fatigue Loading No. Cycles: 6000	10000	Total Set	Load in lbs. used in Fatigue Test	Stress Rover Wahl Formula	Number Cycles to Failure
B-1	6.54	5.09	1.45	.285	.02	.02	.01	.07	.02	.14	7859	170000	21900
B-2	6.50	5.16	1.34	.260	.02	.01	.01	.03	.01	.08	5634	130000	86400
B-3	6.39	5.11	1.28	.250	.01	.01	.01	.00	.00	.03	5332	120000	138600
B-4	6.04	5.00	1.04	.208	.01	.00	.00	.01	.00	.02	4799	110000	451800
B-5	6.15	5.08	1.07	.211	.01	.01	.01	.01	.00	.04	6520	150000	70300
B-6	6.14	5.10	1.04	.204	.01	.01	.00	.01	.00	.03	4493	100000	376400
B-7	6.04	5.09	.95	.187	.01	.00	.00	.01	.00	.02	4132	95000	580100
B-8	6.01	5.03	.93	.195	.01	.00	.00	.01	.00	.02	3749	80000	2074500 No Failure
B-9	5.96	5.03	.93	.185	.01	.01	.01	.00	.00	.02	4040	95000	2331300 No Failure

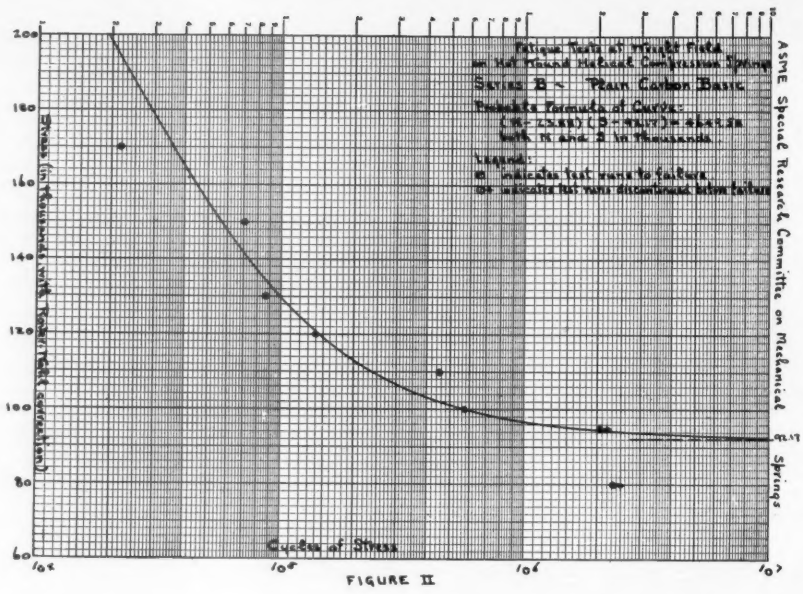

FIGURE II

responding to the results of the fatigue tests, and this equation was found to be:

$$(N + 23.88)\ (S - 92.17) = 4649.58$$

(both S and N in thousands). Figure II shows a graphical plot of this equation, with the test observations.

✦ ✦ ✦

THE result of the analysis is a probable figure for the endurance limit of 92.170 psi, about 25% higher than the fatigue limit of Series "A". This, as far as it goes, supports the suspicion that the life of a helical spring is **not** measured by the augmented stress due to curvature of the bar. On examining the data further, we find a quite remarkable state of affairs. The average Rover-Wahl correction for the seven springs included in the Series "A" fatigue test analysis is 1.3015, and of the seven Series "B" springs 1.5562. Applying these factors to the respective fatigue limits, to reduce them to stress figures as given by the conventional formula (average around the perimeter of the bar), we get 56.450 psi for Series "A" and 59.230 psi for Series "B". These two values differ by only 5%, a variation which can probably be considered as within the limits of reproducibility of a series of fatigue tests. Therefore, on the face of the results, it would appear that the stress augment due to bar curvature has no effect whatever on the endurance of a helical spring.

✦ ✦ ✦

THIS result is so utterly at variance with present ideas on fatigue theory, that further experimental work is imperative. Arrangements will be made for additional tests along these lines as soon as practicable. In the meantime, it may be permissible to speculate for a moment on the implications of the result, assuming that it is finally substantiated.

✦ ✦ ✦

A GOOD deal of research has been done in the last few years on the effect of chemical and mechanical notches on the fatigue of metals. The important results are summarized in a recent paper by Dr. McAdam and Mr. R. W. Clyne, ("Influence of Chemically and Mechanically Formed Notches on the Fatigue of Metals" published as Research Paper No. RP-725 of the Bureau of Standards). In the graphic presentation of results, ordinates of the charts are "percentage damage" values; i. e., the reduction in endurance limit due to a notch, expressed as a percentage of the endurance limit of the unnotched material. Abscissae of the graphs are ultimate strength values.

✦ ✦ ✦

A STUDY of the data reveals these facts:

(*Please turn to Page 41*)

COLD WORKING OF METALS FINISHED PRODUCTS

Cold Worked Metals ✦ ✦ ✦ Cold Formed or Machined Products ✦ ✦ ✦ Cold Heading

1. Metallurgy and Research
2. Processes and Machinery of Production
3. Cold Heading
4. Cold Forming and Finishing Operations
5. Extruding

Vol. 13 JANUARY, 1938 No. 1

Aluminum Wire And Rod Products

By J. F. Coneen,
Edgewater Works,
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A description of machines and processes used in producing the bulk of products made from aluminum rod and wire. ✦ ✦

ALUMINUM wire and rod products fall into two general classes, (1) standard products, such as screws, nuts, bolts, rivets, and the like, and (2) a variety of products of special design, including hair curler parts, smoking pipe extensions, gasoline line fittings, radio knobs, outboard motor parts, camera parts, automatic pencil parts, and others too numerous to mention.

✦ ✦ ✦

WIRE and rod products are either machined from rod on screw machines or else upset from wire on heading machines as the initial operation. Either class may or may not receive secondary operations or finishing procedures. These additional steps depend upon the product itself and the use to which it will be put.

✦ ✦ ✦

THE machines used in the production of aluminum screw machine products are those which can be used on other metals. Only slight changes in procedure are required. The changes, when necessary, are made in the tooling, the tool angles, the feeds and speeds.

AUTOMATIC screw machines for aluminum are of two distinct types, the one being the single spindle type, the other the multiple spindle type. The former have one spindle which contains the rod of the stock to be worked. The tools are in a special turret, rotating to bring each tool in turn into position.

✦ ✦ ✦

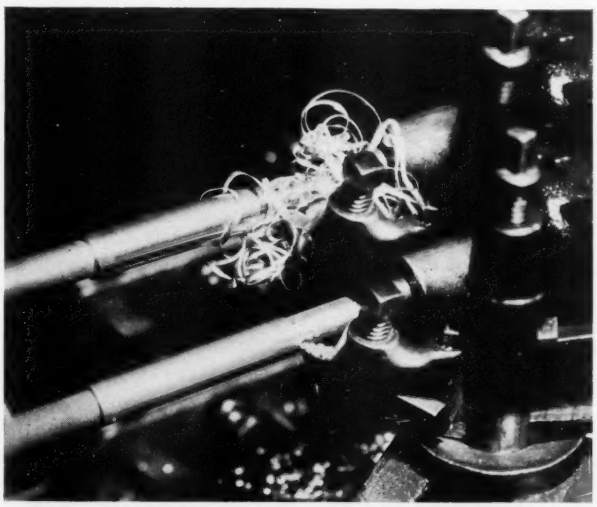


Fig. 1. Comparison between an aluminum free-cutting alloy (below) and a non-free-cutting alloy. Note the small chip size produced by the tool on the lower piece. ✦ ✦ ✦ ✦ ✦

MULTIPLE spindle machines have four, five, six or even more work spindles in a head. This head rotates to bring the rod of stock into position. The tools are in a non-revolving turret. Both machines have end working tools located in the turret and independently operated cross slides which advance the tools against the work at right angles to the axis of the rod.

✦ ✦ ✦

TO make an aluminum automatic screw machine product, the rod of stock is held in a hollow spindle and is rotated at fairly high speeds. The stock is fed out automatically by means of cams as soon as the piece is completed. Then the tools repeat their operation to form another piece.

✦ ✦ ✦

IN the case of single spindle machines, the rod of stock is first fed against the stock stop, then the turret is rotated, bringing the first tool into position. While the stock is rotating, the tool is held stationary, so far as rotation is concerned, but it is advanced by the cam upon the work.

THE advance of the tool is regulated by the cams, and upon completion of its cut the tool is backed away from the work and the next tool in the turret is brought into position through the indexing of the turret. The turret is so fashioned that it may accommodate six tools—five in addition to the stock stop. All six can be used in sequence.

✦ ✦ ✦

THE tools in the cross slides which advance at right angles to the axis of the stock, may overlap in their operations with some of the turret tools. If this interferes with the turret tools, the cross slides may have to be operated alone. One of the cross slide tools usually cuts the finished piece off and thus leaves the way clear for a repetition of the tool cutting operations for the manufacture of a new piece.

✦ ✦ ✦

IN the multiple spindle machines the work is fed against the stop as before. A cross slide tool may also be operated in this position, so that the two tools may be cutting at the same time. After the tools have made their cut they retreat from the work and the spindle head rotates to bring a new rod of stock into the first position, while the previous rod is advanced to the second position. Here again both a side working tool and an end working tool may be advanced to cut the stock. The machine action is repeated as often as necessary, depending upon the number of spindles.

✦ ✦ ✦

THE tools which operate from the turret positions of either machine are turning tools (box tool, balance turning tool, hollow mill), boring tools (drill, center, counterbore, reamer), threading tools (taps and dies), knurling tools, recessing tools, and swing tools. The latter usually cut tapers or straight lengths by an auxiliary action of the cross slides. There are three types of side working tools. The form tools cut a form into the work which was previously put on the tool, the shaving tools take a light cut and finish to a close dimension, the knurling tools come next, and the cut-off tools separate the work from the stock. These tools are very similar to those used on other metals, and many times aluminum alloys have been substituted for other metals without the necessity for changing any of the tools in a set-up.

✦ ✦ ✦

FOR cutting aluminum-copper alloys it is desirable to use a rake on the tools. Little rake is needed on the free-cutting alloys, for they produce a broken chip which does not foul the tools. The flutes on drills, taps, reamers, and

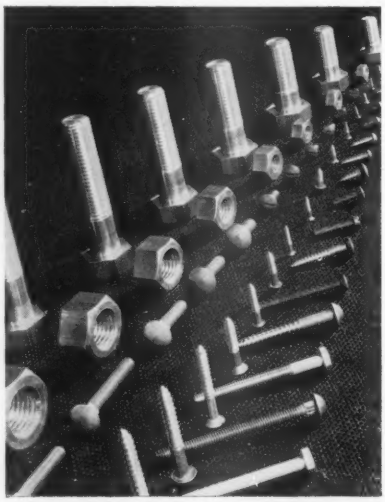


Fig. 2. Various kinds of aluminum wire and rod products. The photograph also shows some of the finishes which can be applied to aluminum. ✦

counterbores should be smooth and polished when cutting aluminum alloys, as they must be with other metals, in order to allow a ready exit for the chips from the work. This adds to the depth of hole which may be cut in one operation, as well as allowing faster cutting and longer tool life. The tools are generally made of high-speed steel, although small drills are often made of carbon steel because the surface speed employed when using these tools is not sufficiently high to cause rapid wear.

✦ ✦ ✦

TOOL angles are most important, and some discussion of them is appropriate. The most frequently used turning tool is the box tool, and for aluminum it is set in the tool holder with a definite clearance angle, usually 8 deg., which is determined by the tool holder. The face of the tool is then ground at an 8-deg. angle to the side, so that the blade will rest along the axis of the work. The angle of the side of the tool to the bottom is determined by the condition of the shoulder to be cut. For 11ST-3, one of the free-cutting alloys, a tool so ground will work satisfactorily, but on 17S-T, a strong aluminum-copper alloy, a V-shaped groove should be ground into the face of the tool, extending to within a few thousandths of an inch of the cutting edge. The groove should be narrow at the bottom and should become wider and deeper toward the top of the tool. The groove serves as a rake, not only making the tool cut more easily but it also coils the chip, guiding it away from the work.

✦ ✦ ✦

CIRCULAR form and cut-off tools have their clearances set by their diameter and by the distance between the center of the tool and the axis of the stock. Taps are generally used as recommended by a tap manufacturer, ranging in size from less than a ⅛-in. two-flute tap to a 1⅝-in. and larger eight-flute tap. Chasers should be ground with 10 to 15 deg. of top rake. Standard twist drills are entirely satisfactory for many holes. For deep holes other types are preferred, such as the straight fluted drill, the high spiral drill with enlarged flutes, and a half-round drill. In all cases it is desirable to have a polished flute for deep holes.

✦ ✦ ✦

SPEED of parts manufactured depends on four things: (1) number of operations, (2) time consumed by the machine for idle movements, such as indexing and feeding the stock; (3) rate of tool advance, and (4) speed of stock rotation.

✦ ✦ ✦

ALUMINUM alloys are generally run at the highest spindle

speed available on the machine, and runs have been made with as high as 800 surface ft. per minute without excessive wear on the tools, although tool wear generally increases with the rate of travel of the tool over the work.

✦ ✦ ✦

FEEDS used with aluminum alloys vary with the requirements of finish, tolerance, shape, and size of the piece. Feed per revolution varies, depending upon the tool, from less than .001 in. to more than .017 in.

✦ ✦ ✦

CUTTING lubricants play an important part in the manufacture of aluminum screw machine products. A paraffin oil, to which a small percentage of fatty oil may be added, is generally used. A copious flow of oil to the tools is necessary to give the high finish which is typical of many of the alloys. High pressure of the oil flow is not necessary.

✦ ✦ ✦

IN the upsetting operation, a wire is fed from a cradle on the upsetting machines by automatic adjustable feed rolls through a cut-off due to a stop. The blank is then cut to length by a shear knife and held between metal fingers while the knife is carried to a point directly in front of the die. As the header moves forward it thrusts the piece into the die and, continuing its stroke, upsets the free metal to fill the head impression in either the header or the die, or both, depending upon the type of piece to be made.

✦ ✦ ✦

AS the header tool is drawn back, a knockout pin in the back of the die thrusts the finished piece from the die. Plentiful lubrication to the wire must be provided, as in all cold forming operations. Where the amount of metal required to form the upset would give a length of wire which could not be controlled in single stroke operation, two header tools are used. Variations in length, shape, and diameter may be made by changing the dies, header tools, and the adjustment of the knockout pins. The smaller single stroke machines will produce rivets or screw blanks a good deal faster than larger machines. Production may range from 75 to 250 pieces a minute.

✦ ✦ ✦

BURRS on rivets or screw blanks are removed by passing the pieces through rumbling barrels. The oil is cleaned from the pieces with sawdust.

✦ ✦ ✦

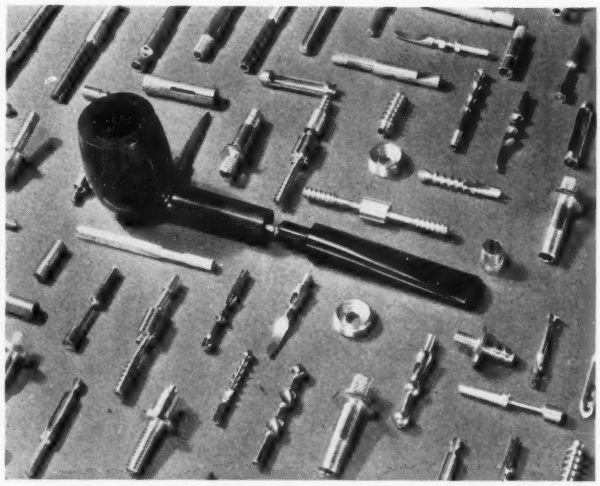


Fig. 3. About 25,000,000 smoking pipes are made in the United States each year, and most of them are supplied with aluminum pipe extensions, such as are shown in the illustration. ✦ ✦ ✦

IN the secondary department the final finishing operations are preformed on machine and wood screw blanks brought over from the rivet department. These blanks require slotting and threading, slotting being done in a hopper feed machine. Machine screws are threaded in the following manner: From a hopper they are picked up under the head and allowed to slide down an inclined slot. At the bottom of the slot is an arm which pushes the blank over to the dies. These dies have the thread form cut into them, and one die is stationary while the other slides. The blank is forced between the two dies. As the movable one slides, it rotates the screw and forces it along the stationary die. The screw is squeezed between the dies in the process and the thread form from the dies is rolled into the blank, leaving the screw finished, except for a wash to remove the rolling lubricant.

✦ ✦ ✦

THE thread on wood screws is cut on an automatic machine. A single-point tool travels along the blank, advancing the pitch of the screw for every revolution of the spindle. A number of cuts, depending upon the size of the screw, are taken in order to complete the thread.

✦ ✦ ✦

IN many cases the machined finish is bright and smooth enough for use, but where this is not the case, a variety of finishes may be applied to aluminum screw machine products. A combination of dipping and burnishing produces a bright finish, in addition to ironing out some of the tool marks. Dipping by itself produces a white, slightly etched surface. If the smooth, high lustre of a buffed finish is required, the pieces are usually previously processed on polishing wheels. Coatings applied by the Alumilite process are playing an increasingly important part in the manufacture of aluminum screw machine products, for by this process it is not only possible to protect the surface of the part adequately, but it is also possible to apply color to the pieces.

The Detroit-Leland Hotel will be headquarters for the 1938 Wire Association Meeting in Detroit.

Exports and Imports of Wire

Exports of Iron and Steel Wire Products in Oct. 1937 and Oct. 1936 (In Gross Tons)

	OCT. 1937	SEPT. 1937	OCT. 1936
Wire rods	7,182	7,571	2,775
Strip steel	7,885	10,811	5,400
Plain, black or galvanized iron or steel wire	4,568	3,091	4,805
Barbed wire and woven wire fencing	2,994	2,563	3,391
Woven wire screen cloth	111	80	85
Wire rope	486	694	.....
Insulated iron or steel wire and cable—see analysis below			
Other wire and manufactures	680	673	526
Wire nails	704	968	725
Tacks	41	35	28
Other nails, including staples	279	288	144
Bolts, machine screws, nuts, rivets and washers	937	1,065	713
Total, these 11 classifications	25,867	27,839	18,592

Imports of Iron and Steel Wire Into the United States (In Gross Tons)

Concrete reinforcement bars	14	149	151
Hollow bar and drill steel	295	105	169
Wire rods	1,282	1,658	1,924
Barbed wire	2,367	1,624	1,289
Round iron and steel wire	308	345	329
Telephone and telegraph wire	1	.....	1
Flat wire and strip steel	288	371	218
Wire rope and strand	309	320	268
Other wire	99	146	381
Hoops and bands	1,310	932	2,225
Nails, tacks and staples	1,010	321	1,997
Bolts, nuts and rivets	69	10	12
Total, these 12 classifications	7,352	5,981	8,964

Exports of Insulated Wire and Cable, October, 1937

	Foreign		To U. S. Possessions	
	Pounds	Dollars	Pounds	Dollars
Insulated iron or steel wire and cable	14,547	$ 3,799	605	$ 107
Rubber-covered wire	880,470	227,306	100,538	28,250
Copper weatherproof wire	115,709	22,131	86,861	16,672
Copper telephone cable	13,610	3,428	14,614	3,714
Other insulated copper wire	381,864	94,839	133,718	27,911
Nickel-chrome electric resistance wire	49,680	60,380	.....	.....
Total, these 6 classifications	1,455,880	$411,883	336,336	$76,654

Pig Iron and Plate Exports Continue Outstanding

WITH a 66,297 ton total, pig iron in October continued as the outstanding product exported from the standpoint of tonnage, the outstanding markets being Japan 37,388; United Kingdom 10,690; Italy 7,534; and Germany 5,793. Next in importance were exports of plate (boiler, fabricated, and 'other'), which amounted to 59,085 tons, the chief outlets being Japan 21,333; Sweden 7,563; Mozambique 4,125; the Soviet Union 3,575; and Canada 3,538.

✦ ✦ ✦

Tin Plate and Ingot Shipments Also Strong

TIN plate exports (while highest in value) represented the third product of importance from a volume standpoint with 36,098 tons going to numerous markets in which the principal ones were Hong Kong 5,288; Argentina 3,122; Brazil 2,783; Japan 2,732; and Canada 2,608. Ingots, blooms, etc., ranked next with a 35,948-ton total going mostly to Japan 27,456; Canada 3,251; British India 2,500; the United Kingdom 1,599; and Mexico 1,121.

✦ ✦ ✦

Japan Maintains Leading Position — Steps Up Purchases

WITH markedly higher purchases in October (96,098 tons against 57,592 tons in September), Japan remained the outstanding taker of American iron and steel products. The outstanding products exported to that country were (in gross tons) pig iron (37,388), ingots, blooms, etc. (27,456), plate (21,333), wire rods (4,876), tin plate (2,732), and shapes (1,060). Canada continued to rank next with a 36,181-ton total consisting of principally black steel sheets (7,629, skelp (3,833), plate (3,538), shapes (3,362), ingots, blooms, etc. (3,251), steel bars (2,792), and tin plate (2,608). Following was the United Kingdom (24,226 tons) whose trade was mostly pig iron (10,960), steel bars (3,505), strip steel (2,222), and ingots (1,599). Brazil took 13,543 tons of mostly rails (4,571), tin plate (2,783), and black steel sheets (1,938). Sweden continued its relatively high level of purchases in accounting for 12,337 tons, the bulk being plate (7,563), pig iron (1,921), and tin plate (1,089). Shipments to the Soviet Union totaled 11,719 tons, the outstanding items being black steel sheets (4,129), plate (3,557), tin plate (1,505), and seamless boiler tubes (1,140). Hong Kong ranked sixth with a 11,220-ton total of chiefly tin plate (5,288), rails (3,590), and barbed wire (1,104).

✦ ✦ ✦

Pig Iron Again Leading Item Imported

PIG iron in October remained the leading product imported on a tonnage basis with an 11,870-ton total coming mostly from British India (7,015), and the Netherlands (4,119). Next ranking were structural shapes (4,097 tons) taken principally from Belgium (3,777). Then came barbed wire (2,367 tons) chiefly from Germany (1,488), the Netherlands (462), and France (209). The solid and hollow bar trade totaled 1,928 tons, the outstanding suppling countries being Belgium (986) and Sweden (545). Hoop and band receipts amounted to 1,310 tons and were imported chiefly from Belgium (1,067) and France (209). Sixth in importance was steel pipe (1,781 tons) purchased principally from Germany (1,436) and Sweden (331).

✦ ✦ ✦

Receipts from British India Highest

BRITISH India was the outstanding source of imports in October with a 5,015-ton total of

mostly pig iron. Next came Belgium whose total of 7,072 tons was chiefly shapes (3,777), hoops and bands (1,067), and solid and hollow bars (986). Germany followed with a 4,262-ton aggregate of mainly barbed wire (1,488) steel pipe (1,436), and nails (819). The Netherlands had a trade of 4,606 tons in which the outstanding items were pig iron (4,119), and barbed wire (462). Sweden ranked next with 3,254 tons, the bulk being wire rods (1,030), solid and hollow bars (545), billets (335), and steel pipe (331).

✦ ✦ ✦

CARD CLOTHING receipts amounted to 26,143 square feet valued at $41,042 in comparison with 20,660 square feet and $27,870 and come principally from the United Kingdom (21,505 square feet valued at $32,474), and Belgium (3,086 square feet valued at $5,878).

✦ ✦ ✦

WIRE HEDDLE imports totaled 421,000 pieces against 1,412,000 pieces and originated in the Netherlands (216,000), and Switzerland (205,000).

✦ ✦ ✦

A TOTAL of 511,875 square feet of WIRE FENCING AND NETTING of the galvanized before weaving grade was received from Belgium. There was no trade in September. Of that galvanized after weaving, the total was 3,429,725 square feet in comparison with 918,956 square feet in September, and the outstanding countries of supply were the Netherlands (2,072,300), Belgium (874,025), and Germany (474,400).

✦ ✦ ✦

WIRE CLOTH AND SCREEN imports totaled 103,212 square feet (155,104 square feet in September) and came chiefly from Germany (69,357), Canada (12,742), and the Netherlands (11,983).

✦ ✦ ✦

THE total for FOURDRINIER AND OTHER PAPER-MAKING WIRES was 28,530 square feet against 38,860 square feet and came chiefly from Germany (12,260), and Austria (11,231).

EXPORTS of iron and steel wood screws during October, 1937 totaled 77,363 gross valued at $12,984. Of this total Cuba took 25,418 gross valued at $5,015; Philippine Islands 17,945 gross valued at $2,075; Venezuela 8,595 gross valued at $1,017; Brazil 6,793 gross valued at $1,800; Argentina 4,950 gross valued at $536; Mexico 3,847 gross valued at $460; Colombia 1,957 gross valued at $339.

✦ ✦ ✦

EXPORTS of brass wood screws during the same month totaled 10,023 gross valued at $4,335. Of this total Canada took 1,838 gross valued at $952; Cuba 1,601 gross valued at $457 Philippine Islands 1,415 gross valued at $571 Brazil 1,385 gross valued at $296 Venezuela 1,140 gross valued at $284.

✦ ✦ ✦

IMPORTS of wood screws during the same month totaled 21,675 gross valued at $1,347 which were supplied entirely by Japan.

Wire Exports From Germany Higher In First Six Months

EXPORTS of wire and wire products from Germany (with the exception of barbed wire and wire nails) continued to increase in the first half of 1937, according to information from the American Consulate General, Cologne. This fact is illustrated by the following table showing quantities and values of these exports during the first six months of 1937 as compared with the corresponding period of the preceding year:

	1936		1937	
	Quantity (Metric Tons)	Value Rmks.	Quantity (Metric Tons)	Value Rmks.
Wire, hot rolled or forged	17,217.1	1,426.000	32,600.9 +90 0/0	2,364.000 +66 0/0
Wire, Cold rolled or drawn: not further worked upon	33,550.3	6,479.000	40,073.0 +19 0/0	8,305.000 +28 0/0
further worked upon	40,144.8	7,268.000	54,763.0 +35 0/0	9,987.000 +37 0/0
Wire rope and wire strand	8,059.1	3,254.000	9,658.0 +18 0/0	3,872.000 +19 0/0
Barbed wire	23,711.5	3,635.000	22,879.0	4,091.000
Wire netting and wire screen	7,037.6	2,376.000	8,745.2 +24 0/0	2,945.000 +24 0/0
Wire brooms, brushes, hooks, box handles, mattress springs, etc.	3,477.0	2,911.000	3,986.0 +16 0/0	3,302.000 +13 0/0
Wire nails	16,942.5	2,512.000	16,195.0	2,430.000

A Review of Recent Wire Patents

No. 2,097,501, ELECTRICAL CABLE AND A METHOD OF MAKING THE SAME, Patented November 2, 1937 by Lester O. Reichelt, Cranford, N. J., assignor to Western Electric Company, Incorporated, New York, N. Y., a corporation of New York.

Over a cable core having a strand binding is applied a covering comprising one or more strips of crepe paper disposed longitudinally with the core and wrapped transversely around the core by means of dies so that where a metal sheath is formed over the paper covered core, the crinkled paper forms a cushioning pad. The paper may be applied, in one embodiment of the invention, prior to the application of a sheath, and in another modification, the paper is applied at the time of stranding the insulating conductors into a core.

✦ ✦ ✦

No. 2,097,518, APPARATUS FOR WINDING MATERIAL, Patented November 2, 1937 by Erwin E. Franz, Cranford, N. J., assignor to Western Electric Company, Incorporated, New York, N. Y., a corporation of New York.

Automatic apparatus is provided to produce electrical coils about a core or axis and consisting of alternate layers of windings and insulative sheets. The sheets are cut and applied intermittently by a pneumatic device over each completed layer of strand.

Complete Descriptions and Drawings of Patents May Be Had for 25 cents. Address, Wire & Wire Products, 17 East 42nd St., New York.

No. 2,098,162, ELECTRICAL CABLE, Patented November 2, 1937 by Malcolm W. Reed, Cleveland, Ohio, assignor to The American Steel and Wire Company of New Jersey, a corporation of N. J.

By forming the cable of series of round wires of different diameters which are selected to combine flexibility with maximum cross-sectional area, a compact cable is provided wherein the separate layers have the same or equal lay, and stranded so as to avoid the nicking which occurs with the usual cross-lay constructions, relatively smaller filler wires being placed in the interstices formed between the layers of larger wires.

✦ ✦ ✦

No. 2,098,163, ELECTRICAL CABLE, Patented November 2, 1937 by Malcolm W. Reed, Shaker Heights, Ohio, assignor to The American Steel and Wire Company of New Jersey, a corporation of N. J.

✦ ✦ ✦

A plurality of wires are helically wound about a core in two concentric layers of the same pitch or lay, the core wire and one-half of the outer layer of wires being of a large diameter, the other half of the outer layer of wires being of a small diameter, and the inner layer being of an intermediate diameter enabling a ratio of metal cross-section to total cross-section of about 84%.

✦ ✦ ✦

No. 2,098,649, BOTTOM STRIP SEAT FRAME CONNECTION, Patented November 9, 1937 by Donald E. Sargent, Jackson, Mich., assignor to Reynolds Spring Company, Jackson, Mich., a corporation of Delaware.

A rigid-non-rotatable connection between a seat frame and its bottom cross strips is provided in which the end of the bottom strip is slit to provide fingers for clamping on opposite sides of a seat frame member.

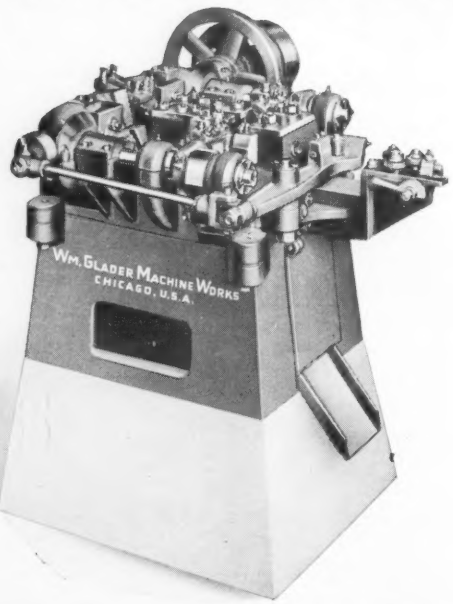
✦ ✦ ✦

No. 2,098,922, APPARATUS FOR MAKING CABLE, Patented November 9, 1937 by Edgar W. McKnight, Bayonne, N. J., assignor to General Cable Corporation, New York, N. Y., a corporation of New Jersey.

To manufacture a compact cable having a plurality of layers of helically laid wires, and to eliminate deep valleys and ridges from the surface of the cable,

700 NAILS PER MINUTE

GLADER BRAD AND FINE NAIL MAKING MACHINE



This machine will produce small nails and brads, 1/4" to 1-1/8" in length from wire 22 guage to 16 guage inclusive.

For Prices and Further Information Address,

Wm. Glader Machine Works

210 No. Racine Ave.,

CHICAGO, ILLINOIS.

A Review of Recent Wire Patents

apparatus is provided for rolling each layer of strands before the next layer is applied, including sets of rolls in the path of movement of the core, one set following each stranding unit.

✦ ✦ ✦

No. 2,098,945, WIRE SPLICER, Patented November 16, 1937 by Robert W. Davis, Lexington, Kentucky.

A portable hand-operated splicer for joining woven wire in fence building includes a U-shaped frame each leg of which carries one of a pair of spaced co-axial twister heads between which a slotted wire holder, pivoted to the base of the frame, is adapted to swing, for engaging the overlapped wires, the twister heads being oppositely rotated through beveled gearing and a hand crank.

✦ ✦ ✦

No. 2,099,040, MANUFACTURE OF METALLIC TUBING, Patented November 16, 1937 by Rene Tondeur, London, England.

Flexible tubing, applicable to Bowden mechanism, is composed of two or more closely interwound relatively laterally displaceable open coils. The leading wire is coiled in a soft condition and then hardened by heat treatment, after which the terms of the following coil are forced between those of the leading coil.

✦ ✦ ✦

No. 2,099,084, APPARATUS FOR STRIPPING ELECTRIC CABLES, Patented November 16, 1937 by Charles Percy Seckham, Wakefield, England.

Lead, paper, or rubber coated cable of any diameter, it is claimed, may be stripped by this apparatus which includes a grooved serrated roller journaled in a pillar bracket for gripping and feeding the cable, and a vertically adjustable block above the roller and carrying a rotatable cutting disc for longitudinally slitting the covering, and a plough member which enters the slit and parts the edges thereof.

✦ ✦ ✦

No. 2,099,106, CARBURETOR SPRING, Patented November 16, 1937 by William M. Ewart, St. Louis, Mo., assignor to Carter Carburetor Corporation, St. Louis, Mo., a corporation of Delaware.

In order to bias the pivoted metering rod of a carburetor to one side of its orifice, a spring is provided having an intermediate coiled portion provided at one end with an arm having a pliable extremity and at the other end with an arm terminating in a hook.

✦ ✦ ✦

No. 2,099,112, APPARATUS FOR TESTING INSULATION, Patented November 16, 1937 by Walter M. Hill, Randallstown, Md., assignor to Western Electric Company, Incorporated, New York, N. Y., a corporation of New York.

Upon passing the wire through the testing unit, a circuit is completed which will energize an indicator, when the insulation is defective, a distributor mechanism being included in the circuit to indicate the exact position of the defect, and a counter mechanism to indicate the length of wire tested and to stop the apparatus when a given length of wire has passed through.

✦ ✦ ✦

No. 2,099,200, SPRING CUSHION, Patented November 16, 1937 by John A. Findora, Adrian, Mich., assignor to Stubnitz-Greene Spring Corporation, Adrian, Mich., a corporation of Michigan.

This spring cushion may be employed in automotive vehicles having uneven body surfaces against which the spring frame fits. Concealed fasteners are provided for securing the trim to the frame.

✦ ✦ ✦

No. 2,099,584, COMPOSITE LATH, Patented November 16, 1937 by George F. Voight, Oakland, Calif.

As a plaster foundation, there is provided a sheet having transverse and longitudinal reenforcing members on its rear face and a wire net on its front face, portions of the net projecting through the sheet and being clamped or engaged between the longitudinal and transverse reenforcing members.

FIRST

There had to be a good heat treating bath
so we originated LAVITE

THEN

There had to be a better furnace
so we invented the internally heated
LAVITE FURNACE

AND THEN TO

assure economical pot life, we developed
LAVITE POTS that are practically
indestructible

FOR

annealing gold, silver, copper, nickel, aluminum,
iron and all alloys of these metals.

Bellis Lavite Furnace in Operation at
Igoe Brothers Wire Plant, Newark, N. J.

The Bellis Heat Treating Co.

BRANFORD, CONN., U. S. A.
and
LAVITE LIMITED, BRADFORD, YORKS, ENGLAND

'Round the World With the Wire Industry

German Notes

THE German wire mesh industry is being reorganized. All manufacturers but one are now members of the German cartel. The export question has been the object of detailed negotiations with the German, British and Dutch exporters, with the main purpose to avoid unfair competition where a customer wants to cut prices by playing one manufacturer against the other. Negotiations with the Dutch and Belgian industry for the purpose of establishing an international cartel have been successful. Austria and Czechoslovakia are also participating in these negotiations so that the establishment of an international cartel may be expected in the next weeks. The other continental wire mesh makers do not export.

✦ ✦ ✦

German Standardization of Wire Netting

STANDARDIZATION of wire netting is progressing. Recently about 30% of all sizes for square netting were excluded as they were thought to be no longer necessary.

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German Machinery Exports

THE demand for wire machinery in Germany continues highly satisfactory and the unfilled orders on hand indicate full operations for about seven months. France, Great Britain and also Japan are buying. Rope making, cable and stranding machinery are in chief demand with wire nail making machinery next. The Latin American business is weak. The trade on used wire machinery is so small that it has lost all its previous importance.

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German Wire Export Market

THE general situation on the wire export market in Germany shows no important change. Shanghai, since the fighting area has moved, has started buying again, and it is estimated that at least 8,000 tons of wire nails will be required, the only difficulty being the question of finance. The Chinese wire industry situated at Shanghai has been almost completely destroyed, and it would require more than a year to bring a part of the industry into operation again. Business is satisfactory from Latin American markets, particularly Brazil and Argentina. Africa is buying little.

✦ ✦ ✦

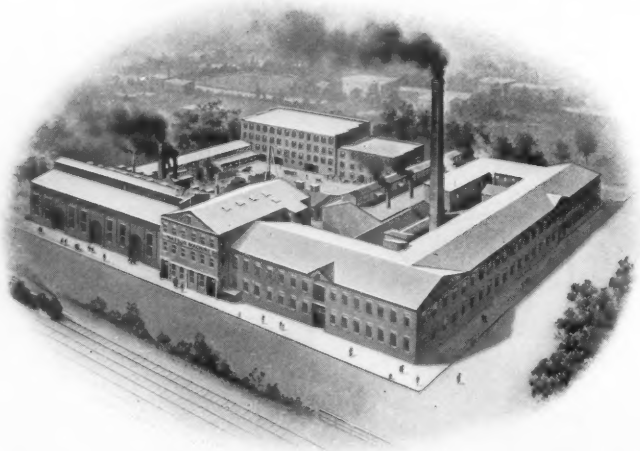
German Wire Rod Production

THE German wire rod production reached 101,750 tons in September and 102,854 tons in October—a new all-time record. This increased production, however, is still insufficient for the demand and rationing continues. The German works are not permitted to book orders more than 10

THE WATSON MACHINE COMPANY

ESTABLISHED 1845

PATERSON, NEW JERSEY, U. S. A.



ENGINEERS MACHINISTS

MANUFACTURERS OF

ELECTRICAL WIRE & CABLE, WIRE ROPE, CORDAGE & GENERAL MACHINERY

YOUR INQUIRIES ARE INVITED

weeks ahead. It is estimated that the accumulated demand, not yet placed, corresponds to at least another 7 or 8 weeks full capacity production; and if the wire industry itself did not ration orders (particularly netting) this would represent another 3 to 4 weeks demand, so that the actual unfilled order volume for wire rods exceeds 20 weeks at the present rate of production which is about 10,000 tons per month higher than the same time last year, when the unfilled orders were about 10 to 12 weeks. The export business as a whole is quiet. The German industry turns down all orders which exceed about 6,000 to 7,000 tons monthly. Imports of wire rods amount to 2,000 to 3,000 tons monthly mainly from Lorraine and Luxembourg. The export demand for open hearth steel wire rods is sharply declining whereas Thomas steel wire rods are in greater demand.

✦ ✦ ✦

Canada Wire & Iron Goods Co., Now Donald Ropes & Wire Cloth Co.

CANADA Wire and Iron Goods Company have just changed the name of their company to Donald Ropes & Wire Cloth Co. The plant is located at Hamilton, Ontario, Canada, and the officers are **A. Donald,** Proprietor and General Manager and **George E. Donald,** Works Manager. The principal lines of manufacture are:

Wire Rope: Round and Flattened Strand in all constructions and diameters as used in the mining, logging, shipping and industrial fields.

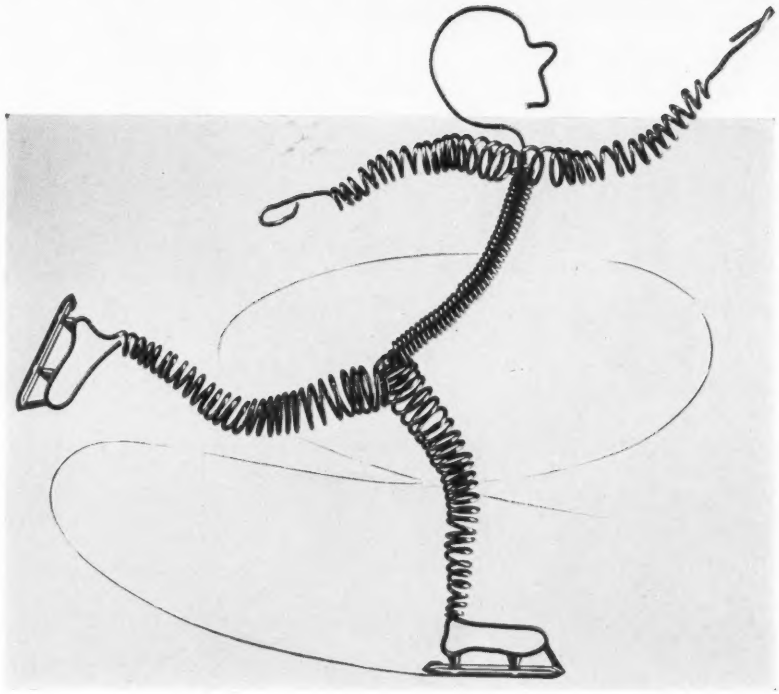
Wire Cloth and Screens: In all metals and alloys as used in the mining, chemical, railway and industrial fields, in all meshes as fine as 200; also Insect Screen Wire Cloth and grades applicable to the hardware trade.

Perforated Metals: Mining, quarry, and paper mill screens.

✦ ✦ ✦

THE plant has approximately one hundred thousand square feet for manufacturing purposes and stocks of wire cloth and wire rope are carried at all principal distributing points from Vancouver to Halifax.

(*Please turn to Page 36*)



Wire

cuts a big figure in production savings

Keep the orders gliding through with smooth precision. Keystone wire will help you skim over margins and make a profit. Reason is, it's made to meet your manufacturing requirements—just the analyses, sizes and finishes your products and methods require. It may be wire regularly in stock. It may be wire made especially for you. But in any case, you'll get what it takes when you call in Keystone.

KEYSTONE

STEEL & WIRE CO., Dept. W, PEORIA, ILL.

HIGH CARBON
or
LOW CARBON

SAMSON SPRING WIRE
KEYSTONE STEEL & WIRE CO. PEORIA, ILL.

Bright... Tinned
Coppered
Annealed
Galvanized

AKTIEBOLAGET LILJEHOLMENS KABELFABRIK

NEW STOCKHOLM, SWEDEN, INSTALLATION OF ROBERTSON CABLE ENCASING PRESS and LEAD MELTING POT

ROBERTSON ENGINEERED is this 25" ram, 1500-ton Cable Encasing Press with 11" bore die-block (range 25 m. m. to 100 m. m.) . . . and the accompanying 19,000 lb. capacity Closed Type Lead Melting Pot, with CO_2 equipment. Not shown, but also installed is a 50 h. p. Hydraulic Pump.

Designed by Robertson, built in Sweden by S T A L, this complete installation is another Robertson endorsement by an international leader.

A weighty intimation that you, too, can profit by Robertson Engineering. All details are yours if you'll write on your letterhead.

John ROBERTSON CO. INC. — *Pioneers~Since 1858*

125-137 Water Street — Brooklyn, N. Y.

'Round the World With the Wire Industry

(*Continued from Page 35*)

Western Insulated Wire, Inc. Opens Plant in Los Angeles

WESTERN Insulated Wire, Inc., the first and only manufacturers of rubber covered wire West of Chicago, have just completed construction of their plant at 1001 East 62nd Street, Los Angeles. Mr. **A. D. Nast, Jr.,** formerly of Sickle, Heath & Nast of Chicago is President, and **E. H. Lewis,** former Designing Engineering in charge of Wire and Cable, of General Electric Company, and later General Manager of the Hatfield Wire & Cable Company is Vice-President. This company will manufacture all types of rubber covered wire such as flexible cord, heater cord, building wire, cord sets, etc.

✦ ✦ ✦

Nail Factory For Manila

EVERY NAIL, bolt and nut which has been used in the **Philippine Islands** has been imported principally from Japan, Belgium, Germany, Czechoslovakia, and the United States. Now a new industry is to be inaugurated — the P. I. Mining Machinery and Electrical Supply Company, Manila—to produce locally nails, bolts and nuts, and a large number of hardware lines. It is anticipated that under present plans nail output will average about 7 tons daily.

✦ ✦ ✦

Wood Screw Cartel Agreement Between Czechoslovakia and Hungary

THE **Czechoslovak** wood screw cartel ("Vrut" Wood Screw Sales Office, Prague) has recently concluded a cartel agreement with 3 wood screw manufacturers in **Hungary,** according to advices from the office of the American Commercial Attache, Prague. The agreement—to remain in effect indefinitely—is for the purpose of offering mutual protection to producers on the domestic and respective foreign markets. Similar agreements are in effect with producers in Austria, Germany, the United Kingdom, and Sweden.

Tentative Specifications of Interest to Wire Men

THE American Society for Testing Materials advises the issue of the following tentative specifications which are of interest to wire men:

Tentative Specifications for:
Zinc-Coated (Galvanized) Iron or Steel Far-Field and Railroad Right-of-Way Wire Fencing (A 116—37 T)
Zinc-Coated (Galvanized) Iron or Steel Barbed Wire (A 121—37 T)

✦ ✦ ✦

THE reason for publishing a proposed standard as tentative is to give industry and all others concerned an opportunity to comment and submit criticisms for the purpose of insuring, when finally adopted, a standard which will be fully adequate and satisfactory.

✦ ✦ ✦

THE American Society for Testing Materials is particularly desirous of securing comments from wire manufacturers in this connection and copies of the tentative specifications can be obtained either from R. E. Hess, Assistant Secretary, American Society for Testing Materials, 260 South Broad Street, Philadelphia, Pa., or from the Secretary of the Wire Association, 17 East 42nd Street, New York, N. Y.

✦ ✦ ✦

Fiberglas

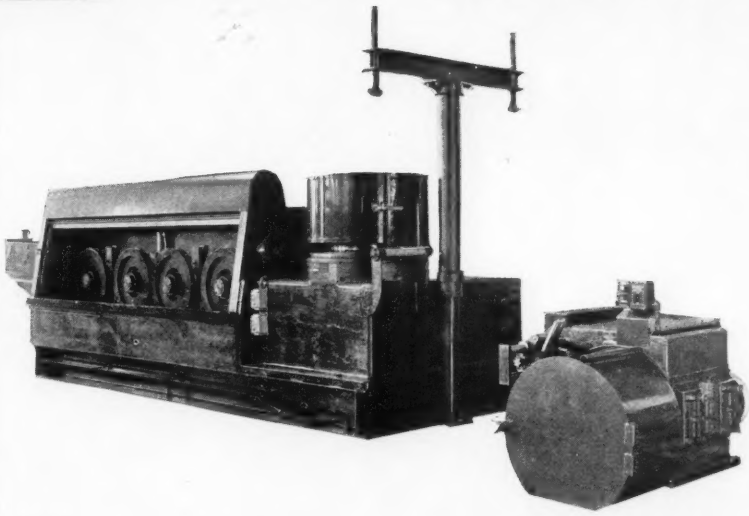
AN announcement by the Research Laboratories of the Owens-Illinois Glass Company of the art of manufacturing and using glass in fiber form marks the beginning of a new chapter in the age-old technology of glass. Processes have been developed since 1932 for the conversion of glass into different types of fiber, ranging in diameter from the relatively coarse, such as are used in air filters and heat-insulating bats, to 4.5 microns (.0002 inch), or finer than the finest of silk fibers.

✦ ✦ ✦

SO far, Fiberglas textile materials have proven practical for several kinds of electrical insulating and covering. Information relating to this product can be obtained by addressing the Owens-Illinois Glass Company, Newark, Ohio.

ES

HIGH SPEED WIRE DRAWING EQUIPMENT



Type "F" Heavy Duty Rod Breakdown Machine

This machine can draw copper, bronze or brass.

Maximum size of entering rod ..... 7/16"
Size of finished wire ..... #2 to #16 B & S gauge
Maximum operating speed ..... 3000 F.P.M.
Number of drawing dies ..... #7-#9-#11 or #13 (minimum slip)
Number of drawing block shafts 4
Maximum motor size ..... 200 H.P.

A COMPLETE line, minimum slip, built primarily for high speed drawing — built for long life, efficient operation, economical production and clean and excellently wound quality wire.

High Speed Insulating Machines For Use With Paper — Cotton — Silk

Saturating and Finishing Equipment For Weatherproof and Code Wire

Taping Machines for Cambric and Paper, etc.

Take-ups — Spoolers — Coilers

Complete Tinning Equipment

Other Equipment for Producing Wire and Cable

Let us show you what our equipment can do towards cutting production cost and improving quality.

ELEVATOR SUPPLIES COMPANY, Inc.

RAHWAY, N. J.

EXECUTIVE AND SALES OFFICE
420 LEXINGTON AVE., NEW YORK, N. Y.

WORKS
RAHWAY, N. J.

WIRE

Liquored Coppered Tinned

Whatever your use of wet drawn or tinned wire, Continental can supply you the desired color, character and weight of finish on base wire of analysis and temper to speed your production, reduce rejections, and add to the appearance and dependability of your product. Liquor finished and coppered in hard, soft, and special stapling; white bronze, extra coppered, and extra liquor finished in hard and soft; liquor drawn bright annealed, dead soft annealed copper wiped, and annealed cleaned copper dipped; also tinned wire, are among those available. Prompt, dependable service on these or any types of manufacturers wire. We invite your inquiries.

CONTINENTAL STEEL CORP.
General Offices: Kokomo, Indiana
Plants at Canton, Kokomo, Indianapolis

CONTINENTAL
STEEL SHEETS AND WIRE PRODUCTS

Wire: Bright Basic, Annealed, *Konik, Special Manufacturers, Galvanized, *Flame-Sealed

Wire Rods, Nails, Staples, Bale Ties, Barbed Wire; Fence — 15 Types; Gates and Fittings

Sheets: Black, Galvanized, Special Coated; Roofing and Siding—14 Styles

*Trade Mark Registered, U. S. Patent Office

Outstanding Personalities of the Wire Industry

J. U. ANDERSON
Treasurer, Pittsburgh Steel Co.

John U. Anderson Named Treasurer of Pittsburgh Steel

JOHN U. Anderson, prominent for years in the iron and steel industry in the Youngstown-Cleveland district, has just been elected secretary and treasurer of the Pittsburgh Steel Co., according to an announcement made by President Henry A. Roemer.

✦ ✦ ✦

ANDERSON was treasurer of Trumbull Steel Co., Warren, O., from 1918 to 1928 when Trumbull Steel was taken over by Republic Iron & Steel Co. In the latter year Anderson became treasurer of Republic Iron & Steel Co., then with general offices in Youngstown. When the Republic Steel Corp. was formed, Anderson was named its first treasurer, retiring several years ago.

✦ ✦ ✦

BORN in Youngstown, O., Dec. 12, 1891, son of a master mechanic in the Haselton rolling mills, Anderson was graduated from Williams college in 1914 and soon afterward became connected with the Trumbull Steel Co.

R. F. Holland, Purchasing Agent, Buffalo Bolt Company

REYMOND F. Holland has been appointed purchasing agent of the Buffalo Bolt Company, North Tonawanda, N. Y., to succeed the late Dennis F. Cullinan. Mr. Holland has been associated with the company since 1917.

✦ ✦ ✦

F. A. Whitehead

MR. F. A. Whitehead, general superintendent of the Copperweld Steel Company of Glassport, Pa., died suddenly on December 4, 1937. Mr. Whitehead had been with the Copperweld Steel Company for the past ten years. He previously had been at Jones & Laughlin, the Milton Screw and Bolt Company, and the Buffalo Bolt Company.

✦ ✦ ✦

Donald F. Clash, Factory Manager, Acorn Insulated Wire Company

THE Acorn Insulated Wire Company, 225 King Street, Brooklyn, New York, announces that Donald F. Clash, has joined the Company as Factory Manager. Mr. Clash has been associated with the Anaconda Wire and Cable Company's Research Division for product development and manufacture.

✦ ✦ ✦

Accept Simplified Plan For Bolts, Nuts, Rivets

NATIONAL Association of Bolt, Nut and Rivet Manufacturers has approved government SPR 169-37 whereby 35 per cent, or approximately 400 sizes, will be eliminated under the simplified practice plan proposed. Work on this plan has been under way for several weeks and has received the endorsement of practically all prominent jobber organizations.

✦ ✦ ✦

THE approval was made at the meeting of the association held at the Waldorf Astoria hotel, New York, N. Y., recently, at which W. E. Braithwaite, assistant director of the simplified practices division of the department of commerce, said that printed pamphlets covering the simplification would be available in about two weeks at 5 cents per copy.

Bell-Mine Pulverized Lime

FOR WIRE DRAWING

AMERICAN LIME & STONE COMPANY · Bell Mine Products · WARNER COMPANY · MANAGEMENT

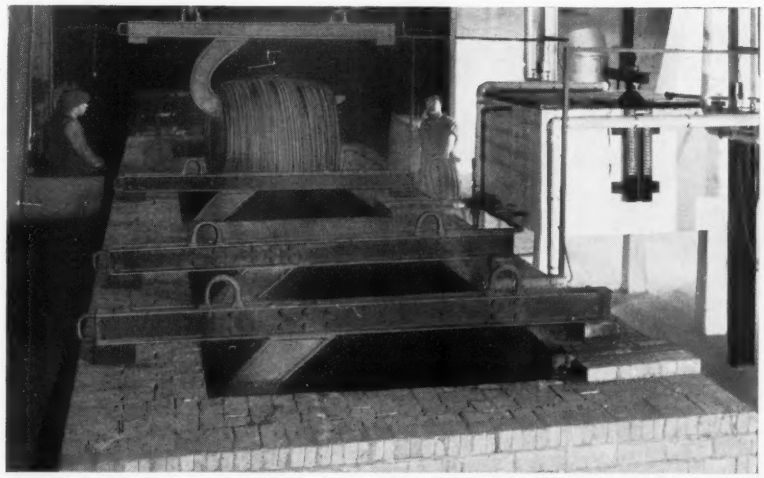
"Bell-Mine" Lime is free from grit and other impurities
.....has a high guaranteed content of Calcium
.... is unusually slow settling in the milk of Lime Box
.. is truly economic in use.

Warner Company

BELLEFONTE DIVISION

SALES OFFICES: PITTSBURGH, PHILADELPHIA, BELLEFONTE, N. Y. CITY.

BASOLIT *Pickling Tanks*



Pictured here is a three section 35 ft. wire pickling tank installed 1933 in the Rock Falls plant of Russell, Burdsall & Ward Bolt & Nut Co., constructed of brick-veneered concrete shell with inner lining of double acid brick and BASOLIT acid proof cement. BASOLIT is also available in combination with rubber lined steel tanks.

BASOLIT Tanks are wear proof and immune against all commercial acids in steel pickling, including hydrofluoric, and many have been in operation from six to eight years without any cost of maintenance or repair.

NUKEM PRODUCTS CORPN.

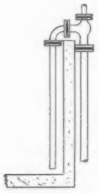
Buffalo, N. Y.

New York · Pittsburgh · Kitchener, Ont.

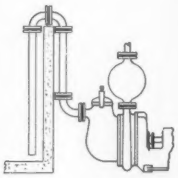
There are several ways to drain an Acid Tank—

Tank outlet

Steam ejector



Self-priming Pump



DURIRON acid-resisting Equipment is usable with any of them.

Duriron Tank Outlets are made in suitable lengths for nearly all types and wall thicknesses of wood, concrete, brick or lined tanks and in sizes from 1" to 8".

Duriron Steam Ejectors operate on 60 pounds steam pressure with a suction lift of five feet; discharge heads up to 30 ft., and capacities up to 6750 gpm. at lower heads with liquid temperature not over 75°F.

Duriron self-priming pumps are available in capacities up to 260 gpm. and for heads up to 115 ft.

We shall be glad to give more detailed information if you wish it.

THE DURIRON COMPANY, Inc.

445 N. Findlay St. Dayton, Ohio

Photo courtesy of Master Wire Die Corporation.

NORBIDE* ABRASIVE . . .

For Efficiently Shaping, Grinding and Polishing Cemented Carbide Wire Drawing Dies.

•

Leaflet giving prices and information sent on request

NORTON COMPANY
WORCESTER, MASS.

* Registered trademark for Norton Boron Carbide

NORTON ABRASIVES

Tanks and Accessories

A NEW publication of the Haveg Corporation, Newark, Delaware, giving complete design and technical data on Haveg Rectangular Tanks and accessories, is now available. These tanks which are suitable for use as pickling tanks are molded from a mixture of special acid washed asbestos and a synthetic phenol-formaldehyde resin.

✦ ✦ ✦

IT is claimed that this composition has strength, toughness and durability and is exceptionally resistant to practically all acids and salts, to chlorine, to the weaker bases, and to many solvents and other chemicals.

✦ ✦ ✦

THESE tanks are non-conductors of electricity and are not subject to electrolysis. Consequently they are very serviceable in electro-plating and electrotying installations as well as being widely applied for pickling and cleaning tanks for the metallurgical industry. A copy of this bulletin can be obtained by addressing the Editor, "WIRE & WIRE PRODUCTS".

✦ ✦ ✦

Triple Control Method for Heat Treatment of Steel

VAPOCARB-HUMP . . . the triple-control method for heat-treatment of steel, is described in a new 36-page catalog just issued by Leeds and Northrup Company. According to the manufacturer, a special effort has been made in this publication to show, more clearly, than in any previously issued, the high-quality of output and far-reaching savings which complete control of tool surface, shape and structure is giving to hundreds of Vapocarb-Hump users. The catalog is especially well illustrated, not only with views of representative installations, but with diagrams, chart records and pictures of many types of tools and dies hardened by the method. Copies may be obtained by addressing Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia, Pennsylvania. Ask for Catalog T-621.

✦ ✦ ✦

Research on Fatigued Properties of Heavy Helical Springs

(Continued from Page 26)

(a) For all styles of mechanical notch, the percentage damage increases at a decreasing rate as the ultimate strength increasing, but never attains a value corresponding to the theoretical maximum stress intensification, and seldom approaching it closely.

(b) For a particular style of notch, the percentage damage in alternating flexure has a different value to that in alternating torsion. For some styles the flexure damage is greater, and vice versa.

(c) For the case of a keyway of the profile type, the percentage damage in flexure is approximately twice that in torsion.

(d) Some of the results on keyways, referred to in (c), were quoted from an investigation by Mr. R. E. Peterson, of our Committee; ("Fatigue of Shafts Having Keyways", Proc. Am. Soc. Test. Mats., Vol. 32, part II, page 413). Mr. Peterson states in his paper that the failures started at the point of tangency of the rounded end of the keyway with the straight side. He also reported tests on specimens with transverse holes of same diameter and depth as the width and depth of his keyways; and the holes caused considerably higher percentage damage than the keyways.

✦ ✦ ✦

NOW, arranging this evidence in logical sequence with relation to a descending scale of percentage damage, we get the following chain:

(1) Any notch, including a transverse hole, causes less percentage damage than would be indicated by the theoretical maximum intensified stress.

(2) A profile keyway, ending in "half a hole", causes less damage than a full hole.

(3) A profile keyway causes much less damage in alternating torsion than in flexure.

✦ ✦ ✦

THE next logical link in our chain would have to do with the effect (in alternating torsion) of a keyway having no end at all; i. e., running the full length of the specimen. At this point we may draw an analogy with our helical spring, in which the locus of maximum stress is a longitudinal element on the perimeter. But inspection of the Rover stress equations shows that the stress gradient in a helical spring extends all round the perimeter of the bar; and a keyway giving this sort of stress distribution would be a highly idealized affair. Indeed, it would probably not be a keyway at all, but something like a flattening, or other slight non-uniformity of the section, rather than a sharp-cornered discontinuity.

✦ ✦ ✦

WE have now gone far beyond the experimental evidence, and are doing little more than guessing; but, lacking the evidence, the natural guess would be that the percentage damage caused by such a non-uniformity would be very low indeed. Looked at in this light, the comparative fatigue results on Series "B" springs may not be so surprising after all.

Part II will be published in February issue.

50 Tons of Copper Wire For Clock Motor Coils

OVER 100,000 pounds of copper wire of approximately the diameter of a human hair will be used by the Warren Telechron Company in Ashland, Mass., in the construction of coils for its synchronous electric clocks this year.

✦ ✦ ✦

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Pittsburgh Regional Meeting Of The Wire Association

IN view of the very decided success of the Regional Meeting of the Wire Association held at Pittsburgh last May, it has been decided that another meeting of this kind will be held late this spring.

✦ ✦ ✦

THE committee in charge, Mr. **J. K. Beeson,** Assistant Manager of Sales, Pittsburgh Steel Company, and Mr. **John Timberlake,** Wire Department, Jones & Laughlin Steel Corporation, advise that they have made definite arrangements to hold a Pittsburgh district meeting of the Wire Association on Friday, April 1 at 7 o'clock in the Cardinal Room of the William Penn Hotel at Pittsburgh.

✦ ✦ ✦

DURING the morning and afternoon of the same day, the plant of the Pittsburgh Steel Company will be open for inspection to members of the Association and their guests, and a buffet luncheon will be provided at the plant for those taking a trip through the mill.

✦ ✦ ✦

AT the evening technical session, Doctor **S. A. Braley** of the Mellon Institute of Industrial Research, will be one of the speakers. The name of the second speaker will be announced shortly.

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ALL members of the Wire Association are invited to be present both at the plant inspection and the meeting. There will be no registration fee or expense of any kind involved to those attending.

✦ ✦ ✦

Rustless Iron & Steel Corp. Opens Cleveland Sales Office

RUSTLESS Iron and Steel Corporation, Baltimore, Maryland, has appointed Mr. **F. J. Elliott,** Cleveland District Sales Manager, and has established a sales office at 731 Society for Savings Building, 145 Public Square, Cleveland, Ohio. Mr. Elliott, who will handle sales and service in the State of Ohio, was formerly with E. F. Houghton & Company.

(*Continued from Page 14*)

spacings between electrodes. With the development of oxide coated filaments and the reduction of operating temperatures, and the minimizing of distortion of wire parts, it has been possible to meet close tolerances. The reader's attention is invited to Figure 2 once again, in order to note the close spacings of the grids and the close wire tolerances. With the advent of multi-electrode tubes, and the appearance of the screen, suppressor, and control grids, these factors have become very important.

✦ ✦ ✦

THE more ductile metals as Molybdenum, Svea metal, and Nickel are used in grid structures, as are the mild tempered forms of Nichrome, Beryllium-Copper, Manganese-Nickel, and others. With the high powered tubes, it has sometimes been necessary to reduce the grid secondary emission, which may be instigated by the heat and radiation from the cathode. The reduction of the secondary emission is accomplished by carbonizing the wires.

✦ ✦ ✦

SCREEN grids require a close mesh wire cloth. They are available in numerable wire sizes and meshes. They are usually constructed of pure Nickel (over 99%) and Molybdenum. Processes have been developed to provide a smooth edge for the wire cloth, which will not unravel. (23). The ends of the shute wires are bent at right angles, and turned in, producing a smoothly finished edge.

✦ ✦ ✦

IN general, wire grid materials must possess low thermal expansion, to avoid distortion under heat radiated by the cathode. It must be possible to form the grid wires into helically coiled shapes. On the other hand, it is possible to form wire gauze for radio tubes of groups of wires, and remove some of the wires by the chemical action of inorganic acids (24).

(*Please turn to Page 44*)

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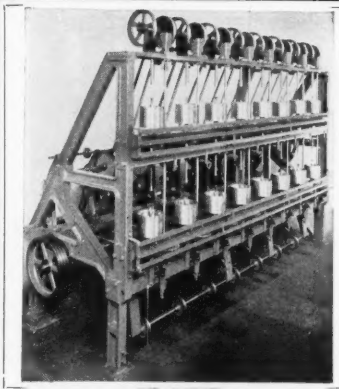

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Offers of Papers for 1938 Meeting

IT is desired that members of the Wire Association and others who have in mind submitting technical papers for the 1938 meeting should advise the Secretary of the Wire Association of this intention prior to March 1, 1938.

✦ ✦ ✦

THE advice of the intention to furnish a paper should be accompanied by a summary outlining the scope of the paper and indicating the features that in the opinion of the author would be of great interest to the members of the Wire Association.

✦ ✦ ✦

CORRESPONDENCE on this subject is invited by the Secretary of the Association. Address Richard E. Brown, Secretary, The Wire Association, 17 East 42nd Street, New York, N. Y.

Wires for Radio Tubes

(*Continued from Page 43*)

Miscellaneous Wire Parts

THE application of wire parts to radio vacuum tubes may be best understood by refering to Figure 5, which illustrates the parts and assembly of a typical radio tube. Looking from left to right, the following numerals are descriptive of their respective columns:

1. Glass flare tubing
2. Flare
3. Electrical Connecting Wires, Mechanical wire and rod supports, and glass exhaust tubing (ready for sealing).
4. Assembled stem
5. Fabrication of stem supports and wire connections to fit tube parts.
6. (Top to Bottom) Mica support—Top shield Mica Spacer—Top Shield—Getter Holder and Getter—Mica Spacer—Bottom Shield.
7. (Top to Bottom) Wire grid lead—Plate — Wire Suppressor Grid — Wire Screen Grid — Wire Control Grid — Coated Cathode Sleeve—Heater Wires.
8. Finished Mounting
9. Ready for Sealing in Glass Bulb.
10. Sealed and Exhausted Tube with grid cap and base.
11. Finished Tube.

✦ ✦ ✦

THUS, from the examination of the above photograph the significance and importance of wire products to radio vacuum tubes may be fully understood. In order to complete the picture, recognition must be accorded to the development of lead-in wires, with thermal coefficients of expansion matching that of glass. Platinum, though satisfactory, was too expensive. Copper-clad and Nickel clad steel wires proved to be a less expensive substitute. However, the more recent Cobalt-Nickel-Iron alloy wires are widely used with hard and soft glasses.

✦ ✦ ✦

IN truth, the development of radio vacuum tubes has relied to a large extent upon the processes and materials of wire products. Though the total quantity required has been comparatively small, the special processing required permits the adoption of only the highest grade products.

✦ ✦ ✦

Bibliography

1. J. Moyer—J. Wostrel—"Radio Receiving & Television Tubes" — McGraw Hill Publishing Company —3d Edition—1936.
2. Rohmheld—U. S. Patent 2,001,548 to General Electric Company, May 14, 1935. "Cathode Electric Discharge Device."
3. Jonker—U. S. Patent 2,014,847 to RCA, Sept. 17, 1935 — "Indirectly Heated Cathode".
4. Richardson, O. W. — "Emission of Electricity From Hot Bodies" — Longmans, Green, & Co.—1921.
5. Dushman, S. "Thermionic Emission"—Rev. Mod. Physics—vol. 2, p. 381 (1930).
6. Compton & Langmuir — "Electron Discharge in Gases" — Rev. Mod. Phys., vol. 2, p. 123 (1930).
7. Becker, J.—"Thermionic Emission" —Bell Sys. Tech. Jl., vol 14, p. 413 (1935).
8. Hodgson & Harley—"Development of Oxide Coated Filaments" — Jl. Inst. of Elec. Engrs., vol. 67, p. 762, June, 1929.
9. Braselton, C. H.—U. S. Patent 2,018,993 to Sirian Lamp Co., Oct. 29, 1935 — "Electron Emitting Elements".
10. Hamada & Nomura, U. S. Patent 2,049,372 to General Electric Company, July 28, 1936—"Electron Emissive Cathodes".
11. McCulloch—U. S. Patent 1,939,075 to Westinghouse—"Coating Composition for Electron Emitting Elements."
12. Randall—U. S. Patent 1,990,204 to Genl. Elec. Co. — Feb. 5, 1935 — "Method of Manufacturing Thermionic Cathode".
13. Loewe & Waldschmidt—Brit. Patent 395,862 to Radio A. G., July 27, 1933—"Cathode".
14. McMaster, L. L. Jr.,—"Factory Processing of Thermionic Emitters"—Radio Engineering—vol. 14, no. 9, p. 14, Sept. 1934.
15. Foulke, T.—U. S. Patent 1,965,585 —G. E. Vapor Lamp Co., July 10, 1934—"Gas Discharge Device".
16. Prescott—U. S. Patent 2,019,504—Bell Tel. Labs.—"Activating Alkaline Earth Oxide Coated Cathodes".
17. German Patent 611,335—"Thermionic Cathode".
18. Loewe & Waldschmidt—Brit, Patent—409,183 to Radio A. G.—April 26,1934—"Thermionic Cathode".
19. German Patent—627,342—Siemens Halske A. G. Jan. 13, 1932.
20. Boer, J. & Jonker & Gessel—U. S. Patent 1,931,647 to RCA—"Introducing Active Metal in Evacuated Electric Discharge Device."
21. N. V. Molybdenum Co., Brit. Patent — 410,268 — May 17, 1934 — "Thermionic Tube Alloys".
22. E. Lowry—U. S. Patent 1,971,076 to Westinghouse, Aug. 21, 1934—"Oxide Coated Emission Filaments."
23. Newark Wire Cloth Company Catalogue No. 32, p. 95.
24. Gloeilampenfabriken, Phillips' — Brit. Patent 409,613—May 3, 1934 "Wire Gauze".

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✦ ✦ ✦

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✦ ✦ ✦

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Detroit Wire Die Co., Detroit, Mich.

DRAW BENCHES—
H. J. Ruesch Machine Co., Newark, N. J.
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
Vaughn Machinery Co., Cuyahoga Falls, O.

ENGINEERS—Consulting Wire Mill
Lewis, Kenneth B., New York, N. Y.

ENGINEERS—Spring
Rockefeller, J. W., Jr., New York, N. Y.

EQUIPMENT—Insulation Testing
Leeds & Northrup Co., Philadelphia, Pa.

EYELETS—Brass or Zinc
Platt Bros. & Co., The, Waterbury, Conn.

FILLERS—Paper for Cable
E. W. Twitchell, Inc., Phila., Pa.

FURNACE CONTROLS — Combustion
Leeds & Northrup Co., Philadelphia, Pa.

FURNACE CONTROLS—Draft
Leeds & Northrup Co., Philadelphia. Pa.

FURNACES—Annealing
Bellis Heat Treating Co., Branford, Conn.
Electric Furnace Co., Salem, O.
Leeds & Northrup Co., Philadelphia, Pa.
Lindberg Engineering Co., Chicago, Ill.
Surface Combustion Co., Toledo, O.

FURNACES—Automatic
Bellis Heat Treating Co., Branford, Conn.
Electric Furnace Co., Salem, O.
Leeds & Northrup Co., Philadelphia, Pa.
Lindberg Engineering Co., Chicago, Ill.
Surface Combustion Co., Toledo, O.

FURNACES—Bright Annealing
Bellis Heat Treating Co., Branford, Conn.
Electric Furnace Co., Salem, O.
Lindberg Engineering Co., Chicago, Ill.
Surface Combustion Co., Toledo, O.

FURNACES—Electric
Bellis Heat Treating Co., Branford, Conn.
Electric Furnace Co., Salem, O.
Leeds & Northrup Co., Philadelphia, Pa.
Lindberg Engineering Co., Chicago, Ill.

FURNACES—Hardening and Tempering
Electric Furnace Co., Salem, O.
Leeds & Northrup Co., Philadelphia, Pa.
Surface Combustion Co., Toledo, O.

FURNACES—Lead Melting
Electric Furnace Co., Salem, O.
Lindberg Engineering Co., Chicago, Ill.
John Robertson Co., Brooklyn, N. Y.
Surface Combustion Co., Toledo, O.

FURNACES—Non-Oxidizing
Bellis Heat Treating Co., Branford, Conn.
Electric Furnace Co., Salem, O.
Lindberg Engineering Co., Chicago, Ill.
Surface Combustion Co., Toledo, O.

FURNACES—Normalizing
Electric Furnace Co., Salem, O.
Leeds & Northrup Co., Philadelphia, Pa.

FURNACES—Wire, Strip & Sheet
Bellis Heat Treating Co., Branford, Conn.
Electric Furnace Co., Salem, O.
Lindberg Engineering Co., Chicago, Ill.
Surface Combustion Co., Toledo, O.

GEARS—Wire Mill
Farrel-Birmingham Co., Ansonia, Conn.

GRINDERS—Roll
Farrel-Birmingham Co., Ansonia, Conn.
Norton Co., Worcester, Mass.

HANDLING EQUIPMENT — Material
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

HOISTS—Electric Traveling
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

HOISTS—Monorail
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

INHIBITORS
American Chemical Paint Co., Ambler, Pa.
Parkin, Wm. M., Co., Pittsburgh, Pa.

INSTRUMENTS—Electrical
Leeds & Northrup Co., Philadelphia, Pa.

INSULATION — Cable or Cable Filler
E. W. Twitchell, Inc., Phila., Pa.

LATHES—Die Reaming
Morgan Construction Co., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.

LIME—Pulverized
Warner Co., Bellefonte, Pa.

LUBRICANTS—For Metal Cutting, Stamping and Drawing
Magnus Chemical Co., Garwood, N. J.

LUBRICANTS—Wire Drawing
Magnus Chemical Co., Garwood, N. J.
R. H. Miller Co., Homer, N. Y.

MACHINERY—Armoring (Cable, Wire Hose)
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
New England Butt Co., Providence, R. I.
John Robertson Co., Brooklyn, N. Y.
Sleeper & Hartley, Inc., Worcester, Mass.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Braiding
New England Butt Co., Providence, R. I.
Fidelity Machine Co., Philadelphia, Pa.
Watson Machine Co., Paterson, N. J.

MACHINERY—Brazing
Thomson-Judd Wire Machinery Co., Lynn, Mass.

MACHINERY—Bunching
Amer. Insulating Mach'y Co., Phila., Pa.
New England Butt Co., Providence, R. I.
Sleeper & Hartley, Inc., Worcester, Mass.
Watson Machine Co., Paterson, N. J.

MACHINERY—Bundling, Scrap
Sleeper & Hartley, Inc., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.
Watson Machine Co., Paterson, N. J.

MACHINERY—Cable, Electric
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
Fidelity Machine Co., Philadelphia, Pa.
New England Butt Co., Providence, R. I.
Thomson-Gibb Electric Welding Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Chain Making
Vaughn Machinery Co., Cuyahoga Falls, O.

MACHINERY—Closing
New England Butt Co., Providence, R. I.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Coil Winding
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Coilers
Broden Construction Co., Cleveland, O.
Elevator Supplies Co., Inc., Rahway, N. J.
Farrel-Birmingham Co., Ansonia, Conn.
Morgan Construction Co., Worcester, Mass.
H. J. Ruesch Machine Co., Newark, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Copper Wire Drawing and Rolling
Elevator Supplies Co., Inc., Rahway, N. J.
Farrel-Birmingham Co., Ansonia, Conn.
H. J. Ruesch Machine Co., Newark, N. J.
Torrington Mfg. Co., The, Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

MACHINERY—Cutting
Broden Construction Co., Cleveland, O.
Farrel-Birmingham Co., Ansonia, Conn.
Hallden Machine Co., Thomaston, Conn.
Lewis Machine Co., The, Cleveland, O.
F. B. Shuster Co., New Haven, Conn.
W. A. Schuyler, New York, N. Y.
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Enameling
Amer. Insulating Mach'y Co., Phila., Pa.

MACHINERY—Extruding
John Robertson Co., Brooklyn, N. Y.
Royle, John & Sons, Paterson, N. J.
Watson Machine Co., Paterson, N. J.

MACHINERY—Flat Wire
Broden Construction Co., Cleveland, O.
H. J. Ruesch Machine Co., Newark, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Forming
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Galvanizing Wire
Broden Construction Co., Cleveland, O.
Sleeper & Hartley, Inc., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Falls, O.

MACHINERY—Gang Winders
H. J. Ruesch Machine Co., Newark, N. J.
Fidelity Machine Co., Philadelphia, Pa.
Watson Machine Co., Paterson, N. J.

MACHINERY—Grinding
Norton Co., Worcester, Mass.

MACHINERY—Insulating
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
Fidelity Machine Co., Philadelphia, Pa.
New England Butt Co., Providence, R. I.
Watson Machine Co., Paterson, N. J.

MACHINERY—Lead Encasing Presses, etc.
John Robertson Co., Brooklyn, N. Y.

MACHINERY—Lead Stripping
John Robertson Co., Brooklyn, N. Y.
Watson Machine Co., Paterson, N. J.

MACHINERY—Lock Washer
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Magnet Wire
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Material Handling
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

MACHINERY — Measuring Wire & Cable
Durant Mfg. Co., Milwaukee, Wis., and Providence, R. I.
New England Butt Co., Providence, R. I.
Watson Machine Co., Paterson, N. J.

MACHINERY—Nail and Tack
Glader, Wm., Machine Works Co., Chicago, Ill.
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Panning
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.

MACHINERY—Pointing
Broden Construction Co., Cleveland, O.
Elevator Supplies Co., Inc., Rahway, N. J.
H. J. Ruesch Machine Co., Newark, N. J.
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

MACHINERY—Rod Mill
Broden Construction Co., Cleveland, O.
Farrel-Birmingham Co., Ansonia, Conn.
Morgan Construction Co., Worcester, Mass.
H. J. Ruesch Machine Co., Newark, N. J.
W. A. Schuyler, New York, N. Y.

MACHINERY—Rolling Mill
Broden Construction Co., Cleveland, O.
Farrel-Birmingham Co., Ansonia, Conn.
Morgan Construction Co., Worcester, Mass.
H. J. Ruesch Machine Co., Newark, N. J.
Torrington Mfg. Co., The, Torrington, Conn.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

MACHINERY—Rubber Strip Covering
Farrel-Birmingham Co., Ansonia, Conn.
New England Butt Co., Providence, R. I.
Watson Machine Co., Paterson, N. J.

MACHINERY—Rubber Tubing and Straining
Farrel-Birmingham Co., Ansonia, Conn.
New England Butt Co., Providence, R. I.
Royle, John, & Sons, Paterson, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Screw Wire
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Special
Amer. Insulating Mach'y Co., Phila., Pa.
Broden Construction Co., Cleveland, O.

WHERE TO BUY, Continued

Elevator Supplies Co., Inc., Rahway, N. J.
H. J. Ruesch Machine Co., Newark, N. J.
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY— Special — Combination Machine for Drawing, Cutting-to-length. Straightening and Reeling Bars from Coil in One Operation (Shumag Type)—
W. A. Schuyler, New York, N. Y.

MACHINERY—Spooling
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
Fidelity Machine Co., Philadelphia, Pa.
Sleeper & Hartley Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Spring Making
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Staple
Sleeper & Hartley, Inc., Worcester, Mass.

MACHINERY—Straightening
Broden Construction Co., Cleveland, O.
Hallden Machine Co., Thomaston, Conn.
Lewis Machine Co., The, Cleveland, O.
H. J. Ruesch Machine Co., Newark, N. J.
W. A. Schuyler, New York, N. Y.
F. B. Shuster, New Haven, Conn.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Stranding
New England Butt Co., Providence, R. I.
Sleeper & Hartley, Inc., Worcester, Mass.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Strip Steel
Broden Construction Co., Cleveland, O.
H. J. Ruesch Machine Co., Newark, N. J.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Swaging
H. J. Ruesch Machine Co., Newark, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

MACHINERY—Taping
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
Fidelity Machine Co., Philadelphia, Pa.
New England Butt Co., Providence, R. I.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Testing Size of Wire
Torrington Mfg. Co., Torrington, Conn.

MACHINERY—Testing Wire
Henry L. Scott Co., Providence, R. I.

MACHINERY—Tinsel Rolling Mills
Amer. Insulating Mach'y Co., Phila., Pa.

MACHINERY—Trolley Wire
Vaughn Machinery Co., Cuyahoga Fall, O.

MACHINERY—Tube Mill
H. J. Ruesch Machine Co., Newark, N. J.
Torrington Mfg. Co., The, Torrington, Conn.

MACHINERY—Welding Wire
Micro Products Co., Chicago, Ill.
F. B. Shuster Co., New Haven, Conn.
Thomson-Judd Wire Machinery Co., Lynn, Mass.

MACHINERY—Winding
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.
Fidelity Machine Co., Philadelphia, Pa.
New England Butt Co., Providence, R. I.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Watson Machine Co., Paterson, N. J.

MACHINERY—Wire Drawing
Amer. Insulating Mach'y Co., Phila., Pa.
Broden Construction Co., Cleveland, O.
Elevator Supplies Co., Inc., Rahway, N. J.
Morgan Construction Co., Worcester, Mass.
H. J. Ruesch Machine Co., Newark, N. J
Scudder, E. J., Fdry. & Machine Co., Trenton, N. J.
W. A. Schuyler, New York, N. Y.
Sleeper & Hartley, Inc., Worcester, Mass.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Torrington Mfg. Co., The, Torrington, Conn.
Vaughn Machinery Co., Cuyahoga Falls, O.
Waterbury-Farrel Foundry & Machine Co., Waterbury, Conn.

MACHINERY—Wire Rope
New England Butt Co., Providence, R. I.
Thomson-Judd Wire Machinery Co., Lynn, Mass.
Watson Machine Co., Paterson, N. J.

MACHINERY—Wire Tinning
Amer. Insulating Mach'y Co., Phila., Pa.
Elevator Supplies Co., Inc., Rahway, N. J.

MACHINERY—Wrapping Wire
Elevator Supplies Co., Inc., Rahway, N. J.
W. A. Schuyler, New York, N. Y.

MATERIAL HANDLING EQUIPMENT—
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

MILLS—Tandem Rolling and Edging
Torrington Mfg. Co., Torrington, Conn.

MONORAIL SYSTEMS—
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

NICKEL SILVER AND PHOSPHOR BRONZE—Rod, Wire and Strip
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.

OVENS—Annealing or Drying
Lindberg Engineering Co., Chicago, Ill.

PAPER—Insulating
E. W. Twitchell, Inc., Phila., Pa.

PATENT ATTORNEYS—
Lancaster, Allwine and Rommel, Washington, D. C.

PICKLING COMPOUNDS—
American Chemical Paint Co., Ambler, Pa.
Parkin, Wm. M., Co., Pittsburgh, Pa.

PIPE AND FITTINGS—
Haveg Corp., Newark, Del.

POTS — Annealing, Case Hardening and Tempering
Lindberg Engineering Co., Chicago, Ill.

POTS—Lead Melting
Farrel-Birmingham Co., Ansonia, Conn.
John Robertson Co., Brooklyn, N. Y.

PRESSES—Hydraulic and Mechanical
Farrel-Birmingham Co., Ansonia, Conn.
John Robertson Co., Brooklyn, N. Y.

PRESSES—Lead
John Robertson Co., Brooklyn, N. Y.

PULLERS—Wire
Scudder E. J., Fdry. & Machine Co., Trenton, N. J.
Sleeper & Hartley, Inc., Worcester, Mass.

PUMPS—Hydraulic
John Robertson Co., Brooklyn, N. Y.

PYROMETERS—
Leeds & Northrup Co., Philadelphia, Pa.

RECORDERS—
Leeds & Northrup Co., Philadelphia, Pa.

REEL AND TENSION STAND—
Fidelity Machine Co., Philadelphia, Pa.
Sleeper & Hartley, Inc., Worcester, Mass.
Torrington Mfg. Co., The, Torrington, Conn.

REEL CRUTCHES—
Watson Machine Co., Paterson, N. J.

REFRACTORIES—High Temperature
Norton Co., Worcester, Mass.

ROD BAKERS—
Morrison Engineering Co., Cleveland, O.

RODS—Stainless Steel
Rustless Iron & Steel Corp., Baltimore, Md.

RODS—Wire—Non Ferrous
Hudson Wire Co., Ossining, N. Y.
Platt Bros. & Co., The, Waterbury, Conn.
Seymour Mfg. Co., Seymour, Conn.

RODS—Wire—Steel
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

ROLLS—
Farrel-Birmingham Co., Ansonia, Conn.

RUST PROOF COMPOUND—
American Lanolin Co., Lawrence, Mass.

SHEET—Steel
Continental Steel Corp., Kokomo, Ind.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

SKIN PROTECTOR—
Magnus Chemical Co., Garwood, N. J.

SOAPS—Industrial and Wire Drawing
Magnus Chemical Co., Garwood, N. J.
R. H. Miller Co., Homer, N. Y.

STAINLESS STEEL—
Rustless Iron & Steel Corp., Baltimore, Md.

STRIP—Brass, Zinc and Non Ferrous
Hudson Wire Co., Ossining, N. Y.
Platt Bros. & Co., The, Waterbury, Conn.
Seymour Mfg. Co., Seymour, Conn.

STRIP—Steel
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Firth-Sterling Steel Co., McKeesport, Pa.
Pittsburgh Steel Co., Pittsburgh, Pa.

TANKS—Compound
Watson Machine Co., Paterson, N. J.

TANKS—Pickling and Plating—
Haveg Corp., Newark, Del.
Nukem Products Corp., Buffalo, N. Y.

TESTERS—Wire
Henry L. Scott Co., Providence, R. I.

TRAMRAIL SYSTEMS—
Cleveland Tramrail Div. of The Cleveland Crane & Engineering Co., Wickliffe, O.

TREADS—Safety
Norton Co., Worcester, Mass.

TRUCKS
Morgan Construction Co., Worcester, Mass.
Vaughn Machinery Co., Cuyahoga Fall, O.

TUBE BENDERS AND FORMERS—
H. J. Ruesch Machine Co., Newark, N. J.

VALVES AND FITTINGS—Acid Proof
Duriron Co., The, Dayton, O.
Haveg Corp., Newark, Del.

VULCANIZERS—
Watson Machine Co., Paterson, N. J.

VULCANIZING PANS—
Amer. Insulating Mach'y Co., Phila., Pa.

WELDERS—Spot and Butt
Micro Products Co., Chicago, Ill.

WIRE—Cold Heading
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

WIRE—Electric
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.

WIRE—Enameled For Coils
Winsted Div. of Hudson Wire Co., Winsted, Conn.

WIRE—Manufacturers
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

WIRE—Nickel Silver and Phosphor Bronze
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.

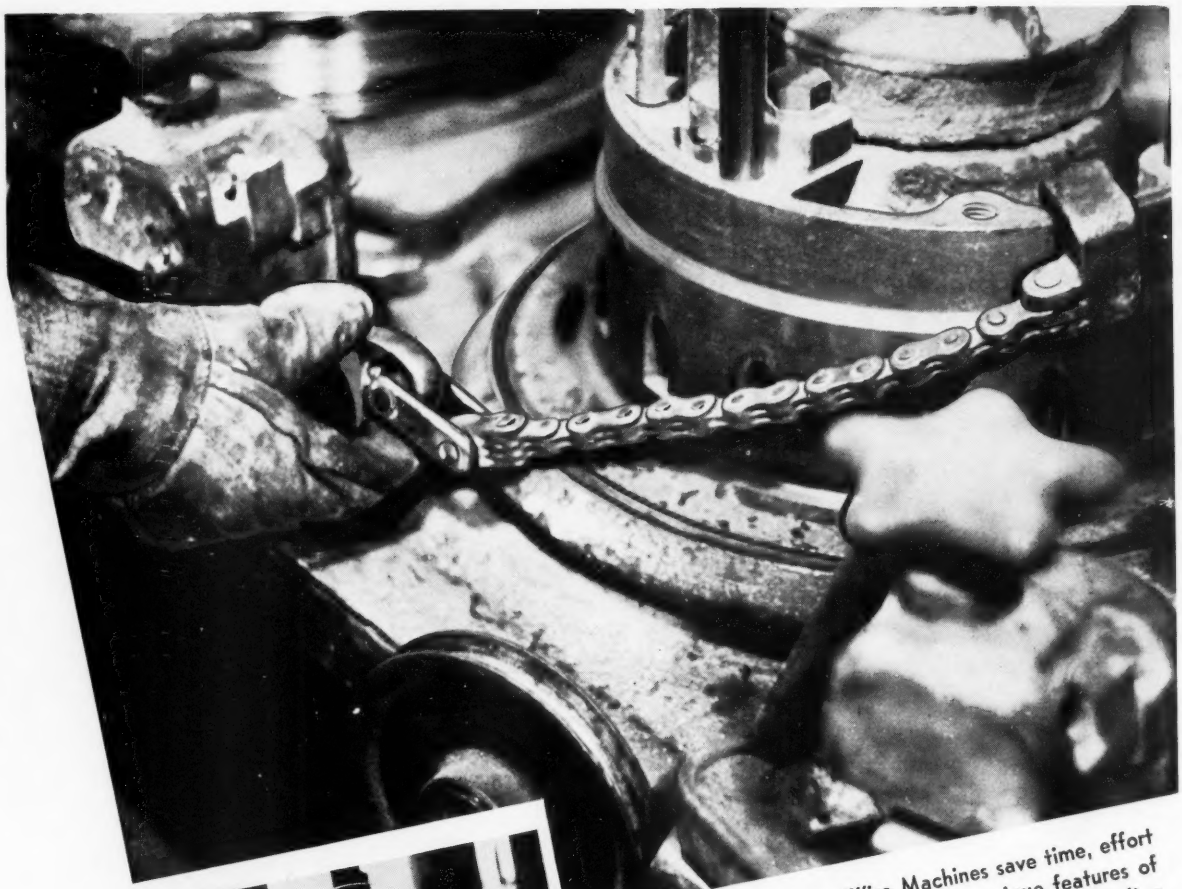
WIRE—Non Ferrous to Specification For Special Purposes
Hudson Wire Co., Ossining, N. Y.
Seymour Mfg. Co., Seymour, Conn.
Winsted Div. of Hudson Wire Co., Winsted, Conn.

WIRE—Spring
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Seymour Mfg. Co., Seymour, Conn.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

WIRE—Stainless Steel
Rustless Iron & Steel Corp., Baltimore, Md.

WIRE—Steel—Also Coppered Steel—Also Galvanized Steel
Bethlehem Steel Co., Bethlehem, Pa.
Continental Steel Corp., Kokomo, Ind.
Keystone Steel & Wire Co., Peoria, Ill.
Pittsburgh Steel Co., Pittsburgh, Pa.
Youngstown Sheet & Tube Co., Youngstown, Ohio.

WIRE AND STRIP—Brass, Zinc
Platt Bros. & Co., The, Waterbury, Conn.

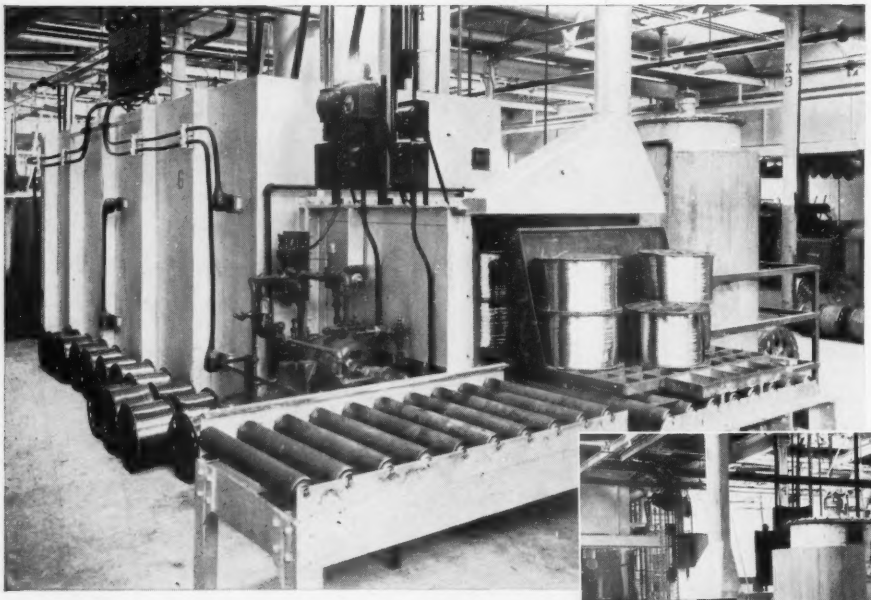


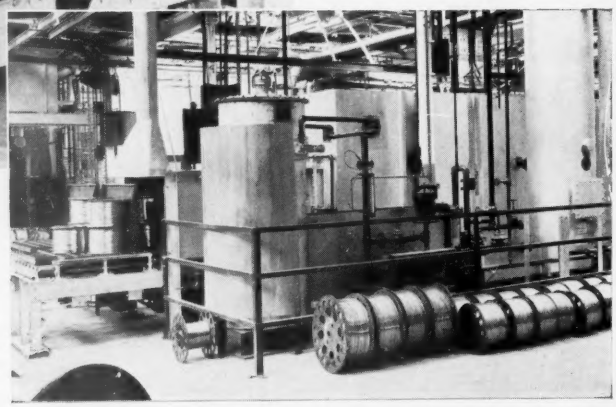
● Morgan-Connor Wire Machines save time, effort and valuable space through the unique features of their construction. They conserve time of threading dies by butt welding, and permit high drawing speeds on both high and low carbon stock. Heavy production schedules are maintained with a minimum of effort. Compact design effects considerable savings in floor space, and the need for special foundations is eliminated. Morgan Construction Co., Worcester, Mass., U. S. A.

MORGAN-CONNOR

Sole European Representatives — Malmedie & Co., Dusseldorf, Germany

Continuous Wire Drawing Machinery





Special Atmosphere

Continuous Furnaces for

Bright Annealing Wire

Uniformly, Economically and Continuously

Wire from the finest gauges to the heaviest sizes is bright annealed uniformly, economically and continuously in special atmosphere furnaces of the type shown above.

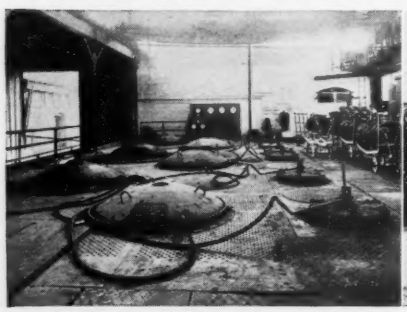
Coiled wire, as well as wire on small spools and large reels, is successfully handled in this equipment. No water seals or vapor of any kind is used, thus staining is entirely eliminated and no drying necessary. The wire is discharged from the furnace uniformly annealed, absolutely bright and dry, ready for shipping, further processing or fabricating. The above is one of several types of electric and fuel-fired furnaces we have developed and built for bright annealing ferrous and non-ferrous wire.

Other recent installations include furnaces for bright and clean annealing brass and copper wire, improved pit type furnaces for normalizing rod and bright annealing steel wire in coils, as well as furnaces for scale-free hardening bolts, springs, etc., billet heating, bright annealing tubing, strip, stampings; carburizing, copper brazing and other heating and heat treating processes.

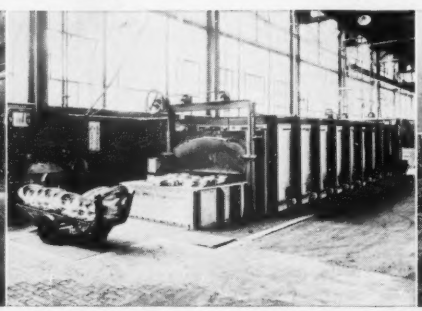
If you are interested in improving the quality of your anneal or heat treatment, increasing production or are contemplating any changes or additions to your furnace equipment, our engineers will be glad to work with you. We specialize on building production furnaces to fit the customer's specific requirements — for any heating process — for any product or production.

The Electric Furnace Co., Salem, Ohio

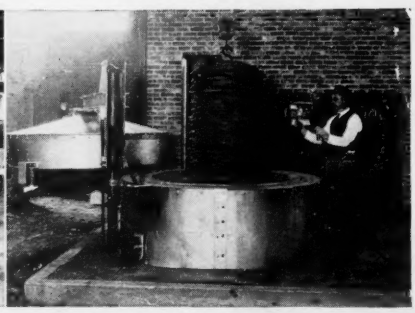
Gas Fired, Oil Fired, and Electric Furnaces—Designed to Fit any Requirement



Gas-fired pits for bright annealing wire and normalizing rod.



Continuous conveyor type, gas-fired furnace annealing wire in coils.



Electrically heated pit type furnace for annealing special alloy wire.